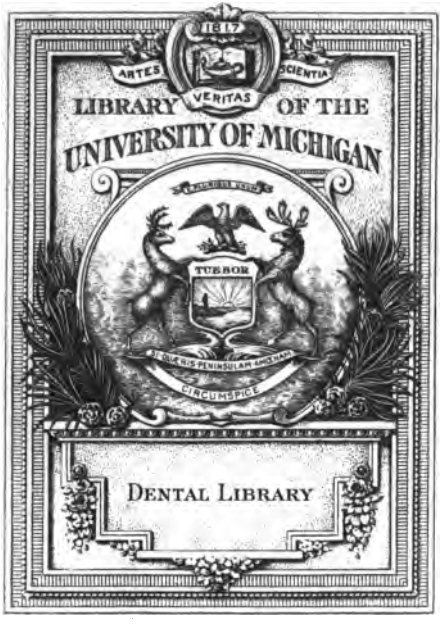
NOTES ON ANÆSTHETICS

UNDERWOOD



NOTES ON ANÆSTHETICS,

WITH

AN APPENDIX

CONTAINING ILLUSTRATIVE CASES AND ENGRAVINGS OF ANÆSTHETIC APPARATUS.

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PREFACE.

I FEEL that the appearance of my name as author of a book on Anæsthetics requires some few words of explanation. It may seem at first sight an anomaly that such a work should not proceed from the pen of a specialist in this department of medicine, and, possibly, I may be taxed with presumption, on the ground that the task I have undertaken demands an extensive personal experience, in order that the statements advanced may carry with them the weight of authority.

This very natural criticism may be disposed of at once by the avowal that I have not relied upon my own resources. In this particular my friend Mr. Woodhouse Braine has been kind enough to read my manuscript and correct, modify, or endorse its statements of practical detail; it was the promise of his assistance that emboldened me to undertake the work, and it is the value of his authority that constitutes its principal claim to the notice of the profession.

I cannot sufficiently thank my friend Mr. Bailey for assistance and advice most readily given, of which I have taken full advantage, more especially in the Appendix. Finally, during the last few years

of pleasant mutual work at Leicester Square, I have not failed to gather many valuable hints from my colleague Mr. Bird.

I have therefore no fear that the following pages will be found to lack the wisdom that is born of experience, or to contain matter in any sense unpractical. I have made free use of the standard literature on the subject, sparing no pains to search out much interesting matter, hitherto scattered through the pages of journals and hidden away in the transactions of learned societies.

I have thought it convenient to arrange such matter as quoted cases, illustrations, and descriptions of apparatus, and some other notes, which, although closely related to my subject, were not absolutely part of it, in a separate appendix at the end of the book, with the object of avoiding a continual interruption of the text, and of making the work readable and clear.

My thanks are due to the Secretary of the Royal Humane Society for the loan of plates Figs. 1 and 2, illustrating Dr. Sylvester's method of artificial respiration; to Messrs. Maw, Son, and Thompson for the engravings bearing their name; and to Messrs. Ash and Sons for the remainder of the blocks, and such descriptive matter relating to them as I have thought fit to use.

Having explained my indebtedness to others in the production of this little book, I have, I trust, made it plain that I must look for praise or blame rather as having discharged the duties, well or ill,

of compiler than those of original author. My work has been principally one of selection and comparison, the weighing of opinions, the condensation of treatises, and the impartial statement of the views of various authorities, but not the putting forward of new and original views of my own.

If I have performed this task judiciously, I do not hesitate to say that the value of the book is enhanced by the fact that the author, not being a specialist, and having no pronounced views of his own to advocate, is content to sink his own individuality, and to discuss the views of others without bias or prejudice.

With these few words of explanation and introduction, I leave the book in the reader's hands, with the assurance that it contains to the best of my knowledge no statement without authority, and in the hope that, while the expert in the science and art of Anæsthetics will meet with nothing very new in its pages, it may prove of service to those who are not experts and feel in need of guidance.

ARTHUR S. UNDERWOOD.

11, *Bedford Square, W.C.*
September, 1885.

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CHAPTER I.

Introductory Remarks.

Almost every one knows that nowadays the terrors of a surgical operation are so modified, by the employment of anæsthetics, that pain has been practically banished from the operating-room. The lay world can appreciate this as well as the profession, and if this diminishing or deadening of pain were the only benefit derived from anæsthetics, we should still be inclined to regard their discovery as one of the greatest achievements of the century. But when we come to consider the number of operations that have been rendered possible by their help—operations which have saved life again and again, yet which, if performed without an anæsthetic, must have themselves caused death from shock; the benefits of the extension of time and the absence of any need for hurrying (rapidity being no longer a matter of great importance in the capital operations); the tranquillity of the patient, and the absence of after depression—it may safely be said that their

use has not only dismissed pain from the operating table, but has also removed many of the chances of death that used to attend the use of the knife, and has brought within the reach of cure diseases which were otherwise beyond it.

In the case of dental operations, the issues involved are, comparatively speaking, small, yet there may exist conditions in which the acute agony of the extraction of a tooth is sufficient to cause absolute danger to the nervous system; in all cases it is undesirable to suffer needless pain, and though the tortures inflicted by dentists must be classed among minor troubles, yet the anæsthetist, when he obviates the necessity of these sufferings, confers a boon, the value of which has been experienced by a large number of the human race.

It is with a sense of proper pride that a dental surgeon considers the question of anæsthetics, seeing that but for the experimental genius of Dr. Wells and Dr. Morton, both American dentists, we might still be in the dark upon this important subject. As the history has frequently been written, and the object of the present manual is simply to supply a practical want, it would be a waste of time and space to do more than summarise it here. Priestley discovered nitrous oxide towards the close of the 18th century, and Sir Humphrey Davy observed that it possessed anæsthetic properties about 1800; but his suggestion, that it might be valuable in surgical operations, does not seem to have been acted upon at that time.

In the year 1844, Dr. Horace Wells, a Connecticut

dentist, observed this property of nitrous oxide, and, moreover, reduced it to practice by administering it in his own surgery; but the results in those early days, with an imperfect apparatus, were not altogether satisfactory. No doubt the discouragement which the world is always ready to shower upon all who advance new ideas, or try to improve upon old ones, was liberally bestowed upon Dr. Wells. At any rate he died a disappointed man, leaving the discovery in its infancy.

Then Dr. Morton, a former partner of Dr. Wells, but who had, strangely enough, received no hint or suggestion from him, instituted a series of experiments quite independently of his old associate, principally upon the lower animals, which resulted in the discovery of sulphuric ether. Much discomfort being experienced from the pungency of this agent, chloric ether was employed instead; and from this Mr. Waldie, of the Apothecaries Hall, Liverpool, separated chloroform, which was first administered by the late Sir James T. Simpson, in the autumn of 1847.

For a time, nitrous oxide, which had had the honour of being first in the field, was eclipsed and almost forgotten. Meanwhile, the tide of fashion fluctuated between the other two anæsthetics. First chloroform superseded ether, because it was more agreeable, then a few fatal cases frightened the public, and a rush was made in the opposite direction. Ether was pronounced less dangerous, because it did not depress the heart's action, but even stimulated it.

This continued until 1861, when Mr. Lister (now

Sir Joseph) published an article in Holmes' 'System of Surgery,' in which he attributed the dangers of chloroform to the omission of a few simple precautions, and brought forward the weighty argument of the actual results of the constant use of chloroform at Edinburgh, and the absence of fatal cases. The Scotch school had administered chloroform on a napkin, without any special inhaler, for many years, they had also disregarded the pulse, and watched only the respiration, for reasons which will be detailed presently; and certainly Syme, Lister, Chiene, and others could point to very wonderful results.*

But in 1864, a committee appointed by the Medico-Chirurgical Society to investigate the subject, published a report in the Society's 'Transactions,' much in favour of ether, as a less dangerous agent, principally because of its stimulating action on the heart.

In 1870, Professor Lister again upheld the cause of chloroform, in an addition to his previous article. Nine years' additional experience still found him in the happy position of being able to say that he had never lost a patient under chloroform; moreover, Mr. Syme's long career of active practice presented a similar unbroken record of satisfactory results.

Professor Lister's position seemed now a very strong one. He explained that, with certain precautions, chloroform was almost perfectly safe, he analysed the deaths that had brought the agent into

* See note C., Appendix, p. 83.

discredit, and showed that necessary precautions had probably been omitted; moreover, he described some cases in which fatal results would probably have occurred, had he himself not interfered to employ the precautions omitted by the surgeon administering the anæsthetic.* Lastly, he described cases in which patients had died from shock when some accident had prevented the administration of the anæsthetic and the operation had been performed without it.† He showed the flaws in his opponents' theories, he pointed out the errors in their practice, and then triumphantly turned to the record of those who followed his own method—a record unsullied by a single failure.

While the rival merits of Ether *v.* Chloroform were being fought out by their several champions, protoxide of nitrogen, which had pioneered the whole question of artificial anæsthesia, was disused and forgotten. It is impossible to say who really first rescued it from the obscurity into which it had fallen, probably Dr. Q. D. Colton is entitled to that honour in America; but as far as England is concerned, we owe our knowledge of nitrous oxide a second time to an American dentist. On the 31st of March, 1868, Dr. T. W. Evans, of Paris, having recently brought over the nitrous oxide gas to this country, exhibited its anæsthetic properties at the Dental Hospital of London, and, moreover, assisted

* See note E., Appendix, p. 88.

† Had chloroform been given, no doubt the fatal result would have been attributed to its use.

the profession in every way to carry out further experiments on this subject.*

Committees were promptly appointed, by the Odontological Society, and by the committee of management of the Dental Hospital, to act in conjunction, and report upon the question. Their preliminary report was very favourable; the rapid anæsthesia (average from sixty-three to eighty-one seconds), the rapid recovery (about 120 seconds average), the absence of after-effects, &c., were all dwelt upon.

In November 1872 the committees published their full report, which was equally favourable. In the volume of the 'Transactions,' Odonto Society, 1872–3, many papers and discussions, which are very interesting and instructive, show what a deep interest was taken in the subject of nitrous oxide, and how widespread its use had become in the four years that had elapsed since its introduction by Evans, and from that time forward this agent became generally preferred to all others for dental operations. Wells who first used it, Colton who revived it in America, and Evans who brought it to England, were all dentists, and all Americans. For this invaluable addition to our scientific possessions, we therefore owe our transatlantic brethren a debt that can scarcely be over-estimated.

In 1880 another committee, appointed by the British Medical Association, published a report of some very careful investigations, the general result

* The date of this event is, by an obvious slip, placed nine years too late in Mr. Coleman's 'Dental Surgery.'

of which was to show that ethidene dichloride was a valuable agent, and that ether in a concentrated form might be administered without any depressing effect upon the heart's action. In their report, this committee once more insisted upon the danger to the heart from the sedative action of chloroform. Sir Joseph Lister, however, again pointed out that as far as chloroform was concerned, there was a source of error in the experiments that rendered this result quite valueless, because the chloroform had been administered through a tube fixed into the trachea, and, therefore, in a concentrated form, and he showed that what was thus demonstrated was not the danger attending the administration of chloroform, but the danger attending the *close administration* of it; in fact, he might have added that by a systematic omission of all points essential to the safe administration of chloroform, the agent might, nay, would be rendered dangerous to life.

The more recent and less known anæsthetics need no mention here. The data, at present accessible, are not sufficient to enable any one to pronounce a very definite opinion upon their merits.

CHAPTER II.

General Considerations.

Before turning our attention to the several anæsthetic agents, which are in common use at the present day, it will be advantageous to consider the physiological effects of anæsthetics in general, and the precautions that may be considered indispensable to the safe administration of any of them.

The continuous inhalation of certain vapours, known as anæsthetics, paralyses the nerve centres in a certain order.

1. *The cerebrum*, destroying volition, so that action is no longer designed or controlled by the intelligence of the individual.

2. *The sensory centres of the cord*, after which movement is erratic, and not even responsive to a sensory stimulus,

3. *The motor centres of the cord*, after which movement ceases.

And, lastly, *the sensory and motor centres of the medulla*, after which respiration, the heart's action, and all the functions of life cease.

If the cerebrum only has been paralysed the

irritation of a sensory nerve will produce a reflex muscular action, as in the case of the unconscious winking of the eye-lid when the conjunctiva is touched, the patient's power of feeling is already gone in one sense, that is, his brain is no longer aware of the touch, nor does he remember it, but his reflex apparatus is still intact. If his finger be pricked he will unconsciously withdraw it; if severe pain be inflicted he will unconsciously struggle. The very manner of his struggling shows that his movements are not under the control of his brain proper; he will do things for which he is irresponsible, and which he would not do were his brain unclouded, and which he will never remember because they have left no record there. The struggle or scream may be exactly synchronous with the injury, but beyond a few habitual actions there is nothing peculiar to the individual, or directed by his will in what he does.

A stage later and the connection between the sensory centres and the motor centres is broken; any movement now is quite irrespective of injuries received; it is perfectly random and irregular; twitchings of the extremities, opisthotonos, rolling of the eyes, and many other muscular phenomena may occur, but they are quite independent of anything that is done to the patient.

A stage later still, and the motor centres are involved, and nothing remains at work but the cardiac and respiratory centres; there is no movement but the movement essential to life; and this is the most favourable moment for operation.

The various centres recover their powers in inverse order.

Before a patient takes an anæsthetic for a long operation, it is of importance to observe certain useful rules with regard to the taking of food and stimulants. I think I shall do well in this connection to quote Mr. Braine's words verbatim :—

"Although I am a great advocate for having the stomach entirely empty, the patient must not be allowed to become faint for want of food. Should the operation take place before 9.30 A.M., no food of any kind should be given; but if it be the usual custom of the patient to take a cup of tea or cocoa about 7, this may be allowed, for having become a habit, it will be missed, and faintness be produced by its omission. If the operation be between 11.30 and 2, let a light breakfast be taken about 8, if that be the patient's regular hour; but if no meal be usually taken till 9.30 or 10 o'clock, then let breakfast be omitted altogether, and a small cup of soup or beef-tea three hours before the time of operating. Never allow the breakfast to be given before the usual time, for in this case digestion does not take place, and vomiting always follows the operation. Should the surgeon fix on the afternoon, let an ordinary breakfast be taken, and the soup or beef-tea be given at 12; on no account let the patient become faint; any tendency in this direction should be combated by the administration of a small quantity of brandy and water."

A great advantage of the early hour (before

breakfast) for administering the anæsthetic, is that there is less time for the patient to think over the approaching operation, and frighten himself about it.

It is as well for all parties concerned that the bladder and rectum should be emptied before administering the anæsthetic.

It is always necessary for the administrator to look in the patient's mouth to see if he wears artificial teeth, and if so to remove them—except in the case of large sets united by springs which are too large to get down the throat. In a dental case, of course, the operator would have discovered this beforehand.

Before operating it is as well for the administrator to try the face-piece on his own face to see that it is in working order.

In case of syncope a few whiffs of nitrite of amyl is an excellent restorative.

The anæsthetist should always be provided with tongue forceps, dressing forceps, scalpel and tracheotomy tube, probang, nitrite of amyl capsules, eau de Cologne, and gags. The most convenient forms of these appliances are illustrated in the Appendix.

CHAPTER III.

Nitrous Oxide Gas.

For short operations, including almost all that fall within the sphere of dental practice, nitrous oxide gas is the best anæsthetic at present known to the profession. The after effects are usually so slight that they are scarcely worth considering. The administration is attended with hardly any appreciable discomfort to the patient, excepting in some rare cases. Lastly, the risk to life is so small, that it may safely be said that supposing a cardiac condition existed that rendered nitrous oxide gas a dangerous agent, in such a case any operation, even the extraction of a tooth *without an anæsthetic*, would be attended with still greater danger. To put the case in other words, every short operation becomes less dangerous to life when performed under gas than when the anæsthetic is not employed.

Dr. Snow said that every case for operation was a case for an anæsthetic, and no doubt he was not far wide of the mark. Of course, *if* a condition existed in which to sit down on a chair a few inches lower or higher than was expected would cause

death from shock, such a patient might die under the gas, but it must be remembered that, in a case of this kind, the extraction of a tooth without gas would as certainly cause death. The gas administered with ordinary care by some one whose entire and undivided attention is devoted to its administration, renders less, and *not* greater, the risk to life, if any such risk be supposed to attend the extraction of a tooth. No one seriously dreads any danger to life from such an extraction, yet a more acute shock cannot well be conceived. There are many conditions of the heart which render a shock of any sort exceedingly dangerous—serious, yet unsuspected conditions, in which the heart, although doing its utmost, is overtaxed; as for example, when disease has enfeebled its powers, when its walls that should be muscular, are mostly fat, or when its valves do not act properly. Under such conditions a man is living on sufferance, for the slightest increase in his heart's beat, or the slightest extra pressure, may force the already enfeebled organ to make its last desperate effort to meet the strain, when it fails and death ensues. I have known cases in which the effort of getting out of bed has been fatal to the already overburdened heart; in such cases the extraction of a tooth would very likely be followed by instant death, but the risk of death would be diminished by the administration of nitrous oxide gas.

The first time chloroform was proposed to be administered at Edinburgh, Mr. Simpson had arranged to give it on a certain day. He was, however, un-

avoidably prevented from attending; the operation was proceeded with without the anæsthetic, and at the first incision the patient died. Chloroform might have saved this patient from the fatal shock, but it certainly could not have added any risk to the operation, although had it been given and had death ensued, the anæsthetic would no doubt have received all the blame.

The number of lives that have been saved by means of anæsthetics, from an almost certain death from shock, is probably very great, while of the deaths that have occurred during artificial anæsthesia, it is not too much to say that several of them would have been certain to have occurred had the anæsthetic not been used; that they occurred *in spite* of its use, and not in consequence of it.

It is to be observed that this statement applies only when the anæsthetic is *properly administered.* The precautions necessary to its safe administration are very few, but they are all essential, and if any of them be disregarded, the element of risk to life is introduced, and the security of the patient is no longer assured. Some of these essential precautions are repeatedly omitted; happily, untoward results of carelessness or ignorance have been very rare, but a risk altogether unnecessary has been run in every such case; the patient has, in happy unconsciousness, been dangerously near death, while the operator has stood with only an accident between him and a very painful event, and chance has kindly stepped in to the rescue.

It is the exact nature of these few precautions that I wish to lay clearly before the reader, and this is the main object of this book.

1st. *The person who administers the gas should have nothing else to do during the operation.*

His undivided attention must be concentrated throughout upon the patient's condition. No one should talk to him or disturb him. Never under any circumstances should the operator administer the anæsthetic himself; the danger of such a proceeding cannot be exaggerated. A patient has been known to die during the extraction of a tooth *without the operator knowing it;* his attention has been entirely absorbed by the extraction, and he has not noticed that death has already taken place. This reflection becomes terribly painful when we remember that, had a competent administrator been watching the case, he would have stopped the operation, pulled forward the tongue, and forced the patient to take a full deep inspiration, and all would, most likely, have been well. When accidents, dangerous to life, occur during the administration of nitrous oxide gas, or any other anæsthetic, the forcible pulling forward of the tongue and the administration of nitrite of amyl, within a few seconds after unmistakable signs of something unusual in the breathing have appeared, will in almost every case remove the difficulty; but should the only person present be occupied with the tooth, an obstruction to respiration may occur which may easily result in death if not promptly relieved. It is, therefore, a rule never to be broken, that one

person should administer the gas and another extract the tooth, and any one who attempts to perform both operations himself is not only without sufficient excuse, but greatly to blame, should an accident occur.

2nd. *The administrator should watch with unremitting vigilance the patient's breathing.*

He should never trust to the pulse as a source of warning to him of possible danger. The results of innumerable experiments, carefully conducted by various committees and private individuals, point to one all-important fact, namely, that if nitrous oxide gas be administered sufficiently to produce death, respiration ceases many seconds before the heart's action; moreover, that immediately after the cessation of breathing, artificial respiration is generally successful. If, therefore, the pulse only is relied on, the first warning of danger may be the death of the patient, for, unless steps are taken to restore life *before* the pulse has ceased, they will most likely be taken too late.*

It is, of course, necessary that the administrator should be familiar both with the phenomena attending normal anæsthesia and with those appearances which are not normal and give cause for uneasiness.

The normal phenomena vary somewhat, but the following description may be taken as more or less typical.

After some nine or ten full respirations the face becomes pale or bluish, and then assumes a slightly darker tint, the fingers often twitch (subsultus

* See notes C. and E. in the Appendix, pp. 83 and 88.

tendinum), the conjunctiva may be touched without any responsive closure of the lids. The last two or three inspirations are accompanied by stertor, not the palatine stertor of the habitual snorer, which in subjects inclined to snoring continues throughout the administration, but the true laryngeal stertor described by Lister. It is a mixture of choking, gulping, and mucous rattling, and exactly resembles the breathing of a person after prolonged immersion under water. This stertor is not always present, but it is so in a very large proportion of cases; it is a very reliable sign that anæsthesia is complete.* The facepiece is now removed and the gulping breathing continues, the lips look bluish, the eyes roll, and in a few cases protrude slightly. The respiration then becomes more quiet, the stertor disappears, the natural colour returns, and with it consciousness. This change of colour is sometimes entirely absent, and patients have been known to become completely insensible without any of the bluish tint here spoken of.

There are little trifling peculiarities in almost every case which are not worth attending to, but the above description is fairly generic. The appearances when seen for the first time are very alarming, but they vanish as quickly as they appear, and leave behind them no after-effects such as sickness or headache, while the anæsthesia is amply long enough for dental purposes, except in a few rare

* The anatomy of these phenomena will be discussed further on.

cases, when a little ether may be required to prolong it.

We will now examine the anatomical and physiological details of the above phenomena.

The *lividity* or blueness is not due to venous congestion, but to the blood not being sufficiently oxygenated. The eye-lid does not close when the conjunctiva is touched; this means that reflex action generally is paralysed,* and, therefore, that there is no danger of unconscious struggling.

The laryngeal stertor is caused by the vibration of the arytæno-epiglottidean folds of mucous membrane, which approach each other and the base of the epiglottis, gradually diminishing the respiratory aperture at this point.†

This approximation of the arytæno-epiglottidean folds will, if the anæsthetic be pushed, end in complete obstruction of the air passage, and it is of vital importance that the nature of this obstruction should be thoroughly understood, and that it should not be confused with a blocking up of the upper part of the passage by the falling back of the tongue or the folding back of the epiglottis. It is important to lay stress upon the exact difference between these

* It has nothing to do with the patient's power of sensation, which is paralysed at an earlier stage. The patient is not conscious of the touch of the finger when he winks his eye-lid, but his reflex nervous apparatus being still awake, the stimulus produces the usual reaction. If he were conscious in a higher sense the lid would close before the conjunctiva was touched.

† The common stertor of snoring is caused by the flapping of the velum palati, and has no signification whatever.

obstructions, because the life of the patient depends upon the administrator knowing exactly what to do should such an accident take place, as it will sometimes *without the premonitory stertor.*

The obstruction caused by the falling back of the tongue, and consequent application of the epiglottis to the upper aperture, will be relieved by pulling forward the tongue till the tip protrudes between the teeth; but the obstruction which is due to the approximation of the arytæno-epiglottidean folds is not affected directly by the position of the tongue, for it, as well as the stertor due to the vibration of the folds, may be produced when the tongue is out as far as it will go. If, however, when the tongue is already as far forward as it will go, it be forcibly pulled against the teeth—although the hyoid bone and the epiglottis do not move, having already moved as far as they can—a reflex action, operating through the nervous system,* causes the folds to recede, and allows free passage for the air. It does so by virtue of a stimulus, received by the nervous system, when the tongue is dragged against the teeth to a degree which, if no anæsthetic had been administered, would have caused pain.

When the impediment to respiration, caused by the mutual approach of these membranous folds, passes into complete obstruction, the respiratory heavings of the chest do not necessarily cease, but

* The nature of which, whether inducing muscular relaxation or contraction, is not exactly understood, and does not much matter at present.

rather become more jerky and irregular. This is a source of danger to the unwary in a double manner—1st, because the movements of the chest-wall may delude the administrator into supposing that respiration is continuing.* 2ndly, because a strong respiratory effort, either of inspiration or expiration when the air-passage is obstructed, has a tendency to stop the heart's action,† and this tendency is increased by the fact that the heart's action is slightly enfeebled at this point of the administration. It is of the highest importance, therefore, to see, by the emptying and re-filling of the supplemental bag,‡ that breathing is really going on, and should it stop, to discontinue the gas and make forcible traction upon the tongue with a pair of forceps (the slight puncture made by the forceps will probably assist the reflex stimulus).

The next precaution is one of less urgency, and yet of some moment, insomuch as it can be shown that in certain cases a disregard of it has led to fatal results; moreover, it is quite possible that some unexplained deaths under anæsthetics may have been due to negligence in this particular. It is *never to operate upon a patient when only partially anæsthetised;* neither begin before full anæsthesia

* A case is reported by Lister in which the anæsthetist quite overlooked a total obstruction of the larynx, being misled by the heaving of the chest-wall into the supposition that respiration was continuing (Holmes, Syst., ed. 3rd. vol. iii. p. 606).

† Huxley explains this in his 'Elements of Physiology.'

‡ See Fig. 4, p. 94, Appendix.

has been reached, nor go on after the effects have begun to fade. We are indebted to Dr. Lauder Brunton for the physiology of the fact that during incomplete anæsthesia a very slight shock may arrest the heart's action, even if its beat be normal, strong, and its structure perfectly sound, for the following reasons:—

The heart's beat is accelerated by the vasomotor nerves and inhibited by the vagus, the stimulus of a shock to the fifth nerve (as in drawing a tooth), affecting both vagus and vasomotor centres at once, and equally when the nervous system is in working order produces no effect on the beat, because one influence counter-balances the other. When an anæsthetic is administered, however, the vasomotor centre is paralysed before the vagus centre; thus for a short time the inhibitory nerve alone is active, and a shock to the fifth would simply produce extreme depression or stoppage of the heart's action. When, however, the anæsthesia is thorough, the reflex sensibility of both centres is abolished, and, therefore, no such effect is to be apprehended. The venous condition of the blood, in nitrous oxide anæsthesia, by stimulating the vasomotor nerves, reduces this danger considerably.

But, apart from the subject of danger to life, it is in every sense an unwise proceeding to continue a painful operation during returning consciousness, for it destroys the confidence of the patient in the anæsthetic, and over and over again has the gas been blamed and discredited when the entire fault

lay with the excessive zeal of the operator, who, fired by an ambition to do a great deal at one sitting, has persisted too long and inflicted some well-remembered twinges at the finish, besides running the risk above alluded to.

To summarise the preceding remarks: If the administrator have his whole and undivided attention devoted to the breathing of the patient—and should the breathing stop, take away the facepiece, forcibly pull outwards the tongue with a pair of forceps, and, if necessary, perform artificial respiration—and if the operation be performed during full and perfect anæsthesia, there is no danger whatever in the anæsthesia from nitrous oxide gas of sufficient duration for the extraction of a tooth.

Minor Precautions.

During the administration of nitrous oxide gas there are many points of practical importance to the comfort of the operator and patient which should be observed, although they involve no graver issues.

Silence. It is a curious fact recently pointed out by Mr. Braine, that, at a particular time during the administration of the gas, the sense of hearing becomes morbidly acute; the ticking of a watch which is only just audible before the gas is inhaled becomes very distinct and loud during the inhalation; the slightest whisper is heard and remembered by the patient while the sense of pain is deadened, and he or she will often repeat afterwards remarks made

before the extraction of the last tooth, although insensible to the pain of the tooth itself. This morbid acuteness of hearing may easily explain the excitement which sometimes attends the earlier inhalation and recovery. There is never any struggling during deep anæsthesia; there is occasionally opisthotonos, which of course is not to be confounded with struggling, although equally inconvenient. When there is struggling, noisy talking, and threatening gestures, it is usually during recovery, and in a very large percentage of cases it occurs in persons addicted to alcohol. "In patients with red faces and dilated capillaries, struggling may be looked for; but that it does not simply depend on the presence of the alcohol is proved by the fact that nitrous oxide gas has been given to partially intoxicated people, without producing the least excitement." *

Undue restraint should be avoided, because it often produces struggling. It is advisable to be on the alert, and ready for the patient, but unnecessary to clutch at him before he becomes violent.

It is, therefore, a wise rule to observe absolute silence, remembering that the patient just before he becomes insensible, instead of getting deafer, is more acutely sensitive to sounds of all sorts; especially is it a foolish thing to talk about either the patient or the operation. Many patients have a dread that the surgeon will begin to operate before they are quite under the influence of the gas, and that they will feel something. Their recollection

* Braine, *loc. cit.*

perhaps of some previous occasion, when the inexperience or timidity of the administrator led him to give an insufficient dose, "and they felt something, and heard everything, but couldn't move" (as they often say); or, perhaps, the account rather coloured and enriched by the imagination of a gossiping friend of some such occurrence, has rendered them apprehensive on this score; in such cases should the clink of an instrument, an observation as to the state of the patient, the difficulties of the case, the mode of operating, or anything of the sort be incautiously allowed, the patient will, in all probability, be terrified half-back to consciousness, will struggle and gesticulate, and afterwards will always imagine the pain to have been felt whatever may be said to the contrary. Indeed, such imaginary troubles have even reached the amusing pitch of a patient declaring that *she felt all the pain, and saw the tooth extracted*, on an occasion when in reality a sudden slipping of the gag and closure of the mouth had prevented the operator doing anything. Absolute silence should, therefore, be kept in the room until the administrator indicates to the operator that he is about to remove the facepiece. This indication should always be given a second or so beforehand, in order that no time may be wasted.

The removal of artificial teeth, or of anything else that might be swallowed, such as a quid of tobacco, a pivoted tooth, &c. The danger of allowing such a thing to remain is sufficiently obvious, but the accident is unlikely in dental practice, since the

operator is presumably already aware of the presence of any such object. An exception may be made in the case of large upper and under sets with springs which could not go down the throat on account of their size. The only point to be observed in this connection is always to *look in the mouth without asking the patient.*

With regard to previous diet, it is not a matter of much importance when nitrous oxide is used, and will be more fully discussed under the head of chloroform. It is sufficient at present to say that the stomach should not be full, that the patient should not be faint through want, and that stimulants beforehand should be forbidden.

To fulfil these conditions is easy if the time for the operation be wisely chosen, but this often cannot be done in dental practice, and for such brief anæsthesia it really does not matter, but there is no doubt that the after-comfort of the patient would be consulted by observing, when possible, the following rule: to administer the gas at a time when the stomach would be empty in the natural course of events, not to omit a meal, which omission would produce an unaccustomed condition of want not at all desirable, but to choose such a time as before breakfast, or three hours and a-half after. It is not wise to interfere with old habits of food-taking. If a light lunch be taken at 1, 3.30 or 4 o'clock would be a convenient time for the anæsthetic; but there is no doubt that before breakfast is the most suitable part of the day, because no time has been

allowed for the timid to fret and brood over the approaching operation, the stomach is naturally empty, and the system refreshed and rested.

It is better to avoid any admixture of air with the gas during the inhalation, not because the admixture produces excitement, but because the air weakens the effect of the gas, and may even nullify it altogether. (Mr. Braine has often demonstrated this point by intentionally giving them mixed or alternately, without producing the least excitement.) If the facepiece be a good one, with a perfect air cushion, there is no likelihood of much air entering with the gas, unless the patient wears a beard, in which case the beard should be rubbed with soap. Previous examination of the chest organs is recommended by Mr. Braine for two reasons, first, because in case of accident, the administrator is certain to be asked whether he examined the patient thoroughly, and to be adjudged guilty of carelessness if he did not. Secondly, because the patient is often reassured by the mere fact of the examination, for every patient thinks there is something peculiar about his or her own case, and is relieved to have all doubts set at rest.

Sir Joseph Lister, on the other hand, systematically omits such examination as having a tendency to frighten the patient, and to suggest dangers which do not exist.

We have already seen that there is no real advantage in the examination, that is to say, it can reveal nothing which would deter us from the

administration of the gas; it is useful or mischievous entirely insomuch as it reassures or alarms the patient. This being so, it must be left to the tact of the administrator to decide for himself which effect is most likely in each particular case; there can be no hard and fast rule laid down. Still, the majority of people would be rather reassured than terrified by being told they were all right in these respects, as most patients fancy some abnormality exists in their own case, and the examination need mean nothing but placing the ear for a moment on the heart. It is undoubtedly an advantage to make the patient take a few deep breaths in order that he may understand what deep regular breathing means, and that nothing unusual is required of him. Without some such preliminary instructions nervous and excitable patients will often occasion a great deal of needless discomfort to themselves and to those assisting by breathing peculiarly; some will puff and blow very fast and excite themselves, others will hold their breath and experience a very unpleasant sense of suffocation, and this generally leads to desperate struggles to get away the facepiece, during which the jerking or shifting of the position of the patient's head renders it impossible to avoid the admixture of air with the gas, and consequent waste of time in producing anæsthesia. It is as well in such cases to allow them to breathe pure air through the inhaler for a few inspirations.

The dress should never be allowed to be so tight as to interfere with full and easy breathing.

Some patients complain of unpleasant after-effects from taking gas through an inhaler which has been previously used for ether; to obviate this, a special inhaler may be used when gas alone is required.

Perfect silence should be observed during the recovery from anæsthesia, in order that the patient should neither become excited, nor remember anything about the operation afterwards. It is a most valuable rule to promote the credit of the anæsthetic by not rousing the patient hastily; after the extraction he should be absolutely undisturbed for thirty seconds at least, especially if he has struggled during the operation; the gag need not be removed, nor the patient's head touched, nor a word said. The last few seconds are exactly the time when all the dreams and sensations afterwards described take place. Patients have often struggled and attempted to seize the operator's hand at the end of the extraction, and yet after a few seconds' absolute, undisturbed silence, have come to themselves remembering nothing; had they been rapidly restored to consciousness they would in all probability have remembered a sense of struggling and restraint, together with the fanciful additions of a half-dreaming state.

We now come to the discussion of the various morbid states which have been supposed to render the administration of gas unadvisable.

This part of the subject may be dealt with by the single general statement that for all minor operations, not lasting more than two or three

minutes, it is almost always better to give the gas, no matter what the condition of the patient; in fact, that few states of health or disease contra-indicate it.

Notwithstanding the fact that this general statement covers the case, it will be more satisfactory to refer in detail to a few complications that have been supposed to exercise a baneful influence, and even to contra-indicate the exhibition of an anæsthetic.

Heart disease is no drawback to the administration of nitrous oxide. Very fatty weak hearts have been supposed to expose the patients to some risk, but there has never been a fatal case traceable to this cause; moreover, as this condition is not diagnoseable during life, it is futile to consider it. Organic disease does not involve any additional risk whatever to the patient.

Pregnancy is no drawback, "even as far advanced as eight months."

Lactation. This function is not affected by the gas, but is liable to be interfered with if such a shock as an extraction be endured without it. *

Menstruation does not interfere in any way with the satisfactory results, and is no reason for postponing the operation.

Syncope. After a considerable loss of blood the anæsthesia is produced very rapidly, and in such a case the patient must be narrowly watched.

Aneurism is a condition in which all struggling should be avoided, and the same may be said of *hernia;* that is to say, any symptom of struggling

* Braine. See note F., Appendix, p. 90.

should not be restrained. It would be better to let the patient push away the facepiece and talk than to restrain him by force; it is generally easy to reassure him and begin again.

Kidney complications have no significance in the administration of nitrous oxide.

Hysteria presents no peculiar difficulties, but a special demand is made on the common sense of those assisting.*

Apoplectic patients, people with short thick necks and of full blooded habits, demand a little care. Their necks should be perfectly free from all constriction, and the head should be rather inclined backwards than forwards; if the chin be bent down towards the chest there is a danger of compressing the veins of the neck and preventing the free return of blood from the head. In such cases again violent struggling involves some risk.

In *phthisical* cases, where the disease is extensive, there is a peculiar source of danger to the unwary administrator. "The anæsthesia deepens after the removal of the face-piece," † so that in such cases less gas must be given, and full insensibility must not be reached.

Chorea, *hemiplegia*, and *epilepsy* do not affect the question, having no influence whatever on the results of the gas. Mr. Braine even recounts a case in which he administered gas to a child *during an epileptic fit* without unusual results.‡

* See Appendix, pp. 78 and 79. † Braine.
‡ See Note F., Appendix, p. 90.

Great age of the patient is no drawback, unless it be in the case of habitual drunkards, when an atheromatous condition of the vesse's may render struggling dangerous, while the very fact of the alcoholism predisposes to struggling.

Summary.

1. If a tooth has to be extracted nitrous oxide gas does not add to, but lessens any elements of danger.

2. The administrator should have nothing else to think of, and should be acquainted with the proper manner of pulling forward the tongue, and of performing artificial respiration; he should also have some experience in the manner of breathing to be expected during anæsthesia.

3. Enough gas should be given to procure perfect anæsthesia during the operation.

4. Perfect silence should be maintained throughout.

5. In the case of phthisical patients, or those of an apopletic, anæmic, or hernial tendency, special care should be exercised.

6. The gas should not be given more than twice to the same patient on the same day.

CHAPTER IV.

M. Bert's Experiments.

I cannot consider the subject of nitrous oxide gas complete without a brief description of the experiments of M. Paul Bert and their results. I am the more induced to discuss this subject, because the few English versions of it, with which I am acquainted, seem to me to give anything but a clear idea of M. Bert's views.

As long ago as 1871, M. Bert commenced a series of papers, addressed to the Académie Royale des Sciences, in which he discussed the subject of "the influence exercised by changes in atmospheric pressure upon the phenomena of life." Many curious and interesting facts were thus brought to light concerning the gases contained in the blood and the tissues, their tension, and the exact nature of the gaseous interchanges which take place in the lungs. This series of communications continued until 1875.

In 1879 M. Bert's researches took a somewhat new departure, although the obvious outcome of his previous work, in the form of a note entitled "Sur la possibilité d'obtenir à l'aide du protoxyde d'Azote

une insensibilité de longue durée, et sur l'innocuité de cet Anesthésique."

The substance of this paper is as follows :—

Protoxyde of nitrogen is widely employed at the present day to render painless the extraction of teeth, but this anæsthesia cannot be prolonged, for the simple reason that as soon as perfect insensibility is obtained, dangerous phenomena of asphyxia appear. This is because the only way to produce anæsthesia is to administer the nitrous oxide *pure*, unmixed with air, therefore, of course, asphyxia is induced *pari passu* with anæsthesia. The reason why nitrous oxide must be administered pure is simply this: in order that a sufficient quantity to anæsthetise should enter the economy, the tension of the gas should be equal to one atmosphere, at a normal atmospheric pressure; this means a cent. per cent. proportion of gas; in other words, the lungs must be *full* of gas, and therefore there is no room for any oxygen. This is the case when the pressure of the atmosphere is normal.

But if the patient be placed in a pressure of two atmospheres the required tension can be obtained by causing him to breathe 50 per cent. nitrous oxide and 50 per cent. air. Under such conditions it ought to be possible not only to obtain anæsthesia, but to maintain a normal quantity of oxygen in the blood, and consequently to preserve the conditions necessary to respiration.

In order to analyse this theory experimentally, a dog was caused to breathe *in an increased atmospheric*

pressure of $\frac{1}{3}$ *atmosphere*, a mixture of $\frac{2}{3}$ nitrous oxide, and $\frac{1}{3}$ oxygen (the tension of the gas in this mixture equals exactly 1 atmosphere). The dog became anæsthetised in a few minutes, the respiration remained normal, the blood retained its colour, the heart its force, and the temperature its normal degree; in a word, all the phenomena of "la vie végétative" were unaffected, whilst those of "la vie animale" were suspended.

After some time the inhaler was removed, and after three or four respirations the animal recovered sensibility and volition; and almost immediately afterwards even gaiety and vivacity.

This rapid recovery, so different from what is observed in the case of chloroform, is owing to the fact that the gas does not undergo any chemical combination in the blood, but remains there in a free state, and therefore escapes directly.

M. Bert's practical application of the foregoing facts was an apparatus consisting of a large cast-iron box with a glass roof, inside which the atmospheric pressure was increased to the required amount. All those who were engaged in the operation were inside the box, and the mixture of gas and oxygen was under the operating table ready prepared. The apparatus was of course hopelessly impracticable except for large hospitals, and, moreover, involved much expense to work. This memoir was read on the 11th Nov., 1878. In the July of the following year another note on the same subject appears in the 'Comptes Rendus.' In this second note the results of sundry

operations conducted on the human subject are detailed. The apparatus had been contrived by MM. Labbé and Péan. A young woman of twenty was the first subject; the result was all that could be desired, and the anæsthesia was maintained for four minutes. It has since been maintained as long as twenty-six minutes. In 1880 M. Bert, speaking on this subject, claimed for his apparatus that it very nearly attained the ideal perfection of anæsthesia. The complicated and costly nature of the apparatus, however, presented such obstacles to its universal adoption, that his ingenious mind had again started on a new voyage of discovery with the object of dispensing with it, and arriving at the same safe and prolonged anæsthesia under the normal atmospheric pressure.

Having heard of the method employed in America of giving the gas intermittently, re-administering as often as signs of recovery appeared, M. Bert employed this method on dogs, but was not prepossessed with the plan, the constant approach of asphyxia being a dangerous and unpleasant concomitant, and evidently distressing to the animal.

What took place was as follows:—

As soon as the anæsthesia was perfect, and asphyxia was threatened, the blood of the animal was saturated with the gas, and his lungs were full of it. At this point he was allowed to breathe pure air. Now it takes about ten respirations to fill the lungs with air, and as long, therefore, for the blood to retake all the oxygen it requires, but during this time

the gas is escaping from the blood, and impoverishing the lungs' contents of oxygen; thus sensibility returns before the blood has been able to recover enough oxygen.

Therefore M. Bert determined to cause the animal, when anæsthetised, to breathe, not air, but pure oxygen, by this means re-oxygenating the blood before consciousness returned; but the gas was eliminated too quickly, owing to the presence of the pure oxygen, and the results did not come up to M. Bert's hopes.

He next attempted to produce a longer insensibility by administering a mixture of gas and oxygen, after anæsthesia had been obtained by means of pure gas. This was more than sufficient for the re-oxygenation of the blood, because the gas present in the mixture prevented the rapid elimination of the gas that was suspended in the blood. Thus, when pure gas was again given, it was not necessary to push it to the verge of asphyxia. By these means the insensibility of a dog was maintained for half an hour.

This plan was, therefore, strongly recommended to the profession by M. Bert, and certainly deserves careful consideration. It has been suggested to me, by Mr. Bird in conversation, that another difficulty, apparently unforeseen by M. Bert, is likely to complicate this method, namely, that individuals differ as to the proportion of gas required to produce anæsthesia; some experience a much more rapid recovery to consciousness than others, and it is, therefore, conceivable that a mixture that would

maintain anæsthesia for one patient would in another case only produce a semi-consciousness, in which reflex action would be active, and only the control of sense and judgment abolished, a condition in which operating is both difficult and dangerous. For dental purposes, as has been already stated, it is unnecessary to prolong the anæsthesia except in very rare cases, and therefore M. Bert's researches are rather of general than special interest.

CHAPTER V.

ETHER.

If an operation is required to be prolonged beyond the limits of the brief insensibility that can be procured by nitrous oxide gas, the agent usually employed to extend the anæsthesia is ether. Ether induces a very much longer stage of insensibility than nitrous oxide, but the objections to its use are also very considerable, and it is always better in dental practice to avoid employing it if possible.

It has a very strong pungent odour, which is regarded by most people as very unpleasant, and often causes vomiting, coughing, and struggling on the part of the patient.

The after-effects are usually also very unpleasant, nausea and vomiting (very serious complications in operations upon the abdomen), headache, dizziness, and general malaise not at all unfrequently following its administration; moreover, it is generally allowed to be not quite so safe as nitrous oxide.

It has been suggested that the administration of ether has been frequently followed by bronchitis, which has more than once proved fatal. It certainly

does produce an irritation of the bronchial tract and an increased secretion of mucus. Perhaps the bronchitis is due to the direct irritation of the vapour, or the cold following its evaporation, or, as suggested by Mr. Braine, to the excess of perspiration damping the under-clothing, and possible draughts caused by the incautious flinging open of windows by the attendant (*the latter seemed a sufficient explanation of the only case quoted by him*). At any rate, after ether has been administered, the patient should be wrapped up warmly as a precaution.

The struggling and subsequent headache common in alcoholic patients are much aggravated if ether be given. The arterial tension is increased, so that the bleeding is much more considerable; this is a protection in major operations from secondary hæmorrhage, as more vessels require to be tied, but it increases the danger of tiresome bleeding after tooth extractions, and in cases with a hæmorrhagic history some consider it wiser to abstain from the use of ether.*

It takes about two and a-half to three minutes to produce anæsthesia. If the necessity for a prolonged insensibility be sufficiently obvious, the best plan of proceeding is as follows:—

1. The rules of diet laid down in Chapter II. should be strictly adhered to.

2. It should be ascertained that the patient is not suffering or very liable to bronchitis or emphysema.

* Mr. Braine does not share this opinion.

3. If the subject be anæmic, extra care is necessary, as the insensibility supervenes more rapidly than in ordinary cases, and should not be allowed to become too deep.

4. In dental cases, should the patient be phthisical, bronchitic, very anæmic, subject to emphysema, or very old and infirm, it will be wiser to do as much as can be done with nitrous oxide alone, and if necessary, to make another appointment, rather than employ ether.

5. To avoid unpleasantness, during the preliminary stages, it is best in all cases to commence the administration with nitrous oxide. After eight or nine good inspirations a sufficient stage of insensibility is reached to commence the exhibition of ether.*

Many authorities pass ether and gas through the same face-piece, but there is an objection to this practice, namely, the face-piece becomes so impregnated with ether that the whole apparatus reeks of it, and afterwards, when gas alone is passed through it, patients frequently complain of the smell and taste, and even in some cases of headache and malaise; thus nitrous oxide, which is distinguished for its freedom from taste and after-effects, is sometimes unfairly charged with producing these symptoms.

It is with the greatest possible diffidence, however, that I mention this objection, seeing that many administrators of the greatest experience and ability adopt this combined method.

* My authority for this statement is Mr. Bird.

The plan advocated by Mr. Braine I will quote in his own words.

"Quickly change the face-piece for the Ormsby or Dublin inhaler. This must be done very rapidly, so that the nitrous oxide which the patient gets rid of by the first expiration, passes through the sponge, and becomes charged with ether-vapour for the first inspiration. This first inspiration is seldom a full one, the glottis taking cognisance of the pungent character of the vapour; but, in a few seconds, this irritation appears to subside, respiration becomes normal, and the patient sinks to sleep without any struggling whatever.

"There is one precaution to be taken in using an Ormsby inhaler when the patient is lying on his back; and that is, to hold the edge of the india-rubber bag between your finger and thumb, so that it does not become completely distended during expiration; because, if this take place, any ether that is on the bag runs at once through the sponge into the patient's eyes and mouth.

"The cold produced by the rapid evaporation of the ether is often so great that the sponge on which it is poured becomes frozen into a hard solid mass; and when in this condition it only gives off a very small quantity of ether-vapour. This is best prevented by warming the inhaler before using it, by placing in it a napkin, or large sponge, wrung out in hot water. If this plan be pursued, the ether-vapour comes off rapidly, the patient gets under its influence quickly, so that a small quantity of ether suffices, and, the

patient having little to get rid of, nausea and vomiting are frequently absent together.

"After having thoroughly anæsthetised a patient, the sponge may be removed, and insensibility prolonged by allowing the patient to breathe into and from the india-rubber bag of the inhaler, admitting fresh air only when the patient appears to require it. In this way I have kept a patient insensible for twenty-one and a-half minutes, the anæsthesia being maintained by the ether which was circulating in the system at the time of the removal of the sponge; the patient, in this way, being allowed to get rid of the ether in the slowest manner possible.

"It may be urged against this method that the patient rebreathes the carbonic acid of his own expired air, and this is true; but from the length of time I have employed this plan, and from never having seen any deleterious results from it, I do not attach any importance to the objection.

"It is clearly the duty of the anæsthetist to administer the anæsthetic to the patient in any position which the surgeon prefers; but I think the most comfortable one for the patient is lying on the side, with one hand and forearm under the pillow, the shoulders being slightly raised, and the neck a little bent, so that the saliva, which is always secreted in large quantities, may run from the lower corner of the mouth, and not be swallowed. This salivary secretion readily takes up ether-vapour, and, if swallowed, is sure to produce vomiting. After an operation, if there be any faintness, of course it is

most essential that the patient's head should be kept low.

"The easiest way to remedy any faintness coming on after the patient's return to bed is to raise the lower end of the bedstead, supporting it on the end of a sofa or a chair, thus making the head and shoulders the lowest part.

"Those practitioners are the most successful ones who succeed in getting their patients insensible the most quickly; and I consider two minutes and forty-five seconds rather over than under the average time it should take to produce complete insensibility. There is no fear of giving ether-vapour too rapidly, or of the ether-vapour being too pungent, so long as the patient breathes easily.

"Occasionally a patient breathes very slowly, and holds his breath, apparently for a long time; but if you breathe synchronously with him, and do not suffer any discomfort, you need be under no anxiety regarding him, no matter how long the time appears.

"Dyspnœa occasionally arises from some thick tenacious mucus hanging about the fauces and epiglottis; and this is most easily got rid of by changing the position of the patient's head from one side to the other, or raising the head somewhat. If, however, the breathing do not improve, then open the mouth wide by means of the tongue forceps, and this, producing the act of swallowing, may put matters straight. If it do not succeed, then pull the tongue well out of the mouth, and cause the patient to make a forcible expiration, by sudden firm

pressure on his thorax with your left hand and forearm. If this pressure be applied sharply, quite at the end of a natural expiration, such a full inspiration follows, that the mucus is forced from its position, and is either coughed up or swallowed."

Much has been written of late about the mixture of ether and chloroform, and it has even been suggested that they will not mix. This statement has arisen possibly from an attempt to mix chloroform with ether of an improper specific gravity. Mr. Bailey assures me that ·720 to ·722 will mix perfectly well with chloroform, and, moreover, does not require warming. The advantages claimed for the mixture are principally with reference to the heart's action, the stimulating properties of the ether being supposed to counteract the depressant effect of the chloroform. It cannot be considered as proved, that there is much danger of this sort to be feared from chloroform alone; and there is no doubt that many cases in which failure of the heart has been cited as the cause of death, mismanagement has at least co-operated. Still, if the mixture offers a reasonable chance of lessening any risk (to whatever cause it may be due), its claim to consideration is established. I would, however, suggest that experimental work be left to those whose long experience entitles them to employ new combinations with confidence; and as this book is not addressed to privileged experts, I shall not uselessly occupy the reader's time by discussing the matter further.

CHAPTER VI.

Chloroform.

For lengthy operations chloroform is at present the anæsthetic most frequently employed. Its action on the heart is at first slightly stimulating, but afterwards depressant, and this latter influence has led many authorities to prefer the use of ether, in order to avoid at least one source of danger, the stoppage of the heart's action. On the other hand, some contend that few cases of death under chloroform have really been traced directly to the depressing influence of the drug upon the heart and the lowering of arterial tension, but rather to certain defects in the manner of administration. Death has occurred more frequently under chloroform than under ether. This is true, but it must be remembered that it has *only once* occurred when administered in the manner advocated by Lister, and in that instance death was due to spasm of the respiratory muscles, and not to any cardiac complication.

The argument in favour of chloroform as urged by Lister, therefore, is that the danger incurred is not due to any effect of the drug upon the heart, but

rather to certain radical errors in the mode of administration. An illustration of the nature of these errors is afforded in the report of the committee on anæsthetics appointed by the British Medical Association. In this report it is stated that to test the effect of chloroform upon the heart, air *saturated* with the vapour was passed through a tube into the trachea. Now, the essential element of safety during inhalation of chloroform is, as will be presently seen, that it should *never be administered above a certain strength*, fixed by Clover at 5 per cent., and by Paul Bert at 8 *grammes of chloroform to* 100 *litres of air*. To experiment, therefore, with a saturated atmosphere is simply to experiment with a poisonous dose; one might as well condemn strychnine because administered pure it produces death.

M. Paul Bert, following in the footsteps of Snow and Clover, has arrived at some very definite statements with reference to the administration of chloroform. In order to apply his principles he has contrived some huge gasometers for mixing his "known quantities." These cumbrous arrangements are a serious drawback to his method, but they need not be considered here, as the only point of real interest is not the mechanism, but the fact that a uniform atmosphere of 8 grammes of chloroform mixed with 100 litres of air will quickly produce perfect anæsthesia, unattended with any dangers or inconveniences, and capable of being maintained for a very considerable length of time. A statement was made by M. Bert ('Comptes Rendus,' vol. xciii. p. 768) before the

Académie des Sciences, in Nov. 1881, the substance of which was as follows: "In the administration of chloroform up to a certain strength, no anæsthesia is produced; beyond a certain strength death ensues; between the two is the working area (zone maniable). If an animal be allowed to breathe a ready-prepared mixture of exact proportions of chloroform and air, in a closed vessel large enough to place the possibility of asphyxia out of the question, (*potash must not be employed to absorb the carbonic acid gas, as it decomposes the chloroform and nullifies the experiment*), the following facts are brought to light:—

1. That the proportions of the mixture forming the limits of the workable area, i.e. between the anæsthetic dose and the fatal dose, are very exact, and that the fatal dose is always exactly double the anæsthetic dose.

2. That between these two points the anæsthesia may be safely maintained for a considerable time—the temperature does not vary, nor the pulse nor respiration fail, and anæsthesia is quickly reached.

3. That the slightest excess beyond the fatal dose is very rapidly followed by death.

4. That no amount of chloroform given weaker than the anæsthetic dose will produce insensibility.

To illustrate these points by an example: In the case of a dog, a mixture of 9 grammes of chloroform to 100 litres of air is the weakest mixture that will produce anæsthesia; 19 grammes to 100 litres of air is the strongest he can breathe without a rapidly fatal result. If he be put in an atmosphere midway

between these two strengths, i.e. in the middle of the working area, 14 grammes to 100 litres of air, he will rapidly become insensible, and he will not experience any period of excitement; he will remain in a mixture of 7 or 8 grammes to 100 litres till he dies without becoming insensible, but if the mixture be raised to 20 grammes, he will very speedily die. For a mouse the anæsthetic dose is 6 grammes, the fatal dose 12 grammes, leaving between them a working area of 6 grammes.

In 1883 another note by the same author occurs in the 'Comptes Rendus' (vol. xcvi. p. 1831). In the interim he had evidently been led to somewhat modify his views of 1881. This note is also worth quoting. "If a dog be caused to breathe a mixture of 4 *grammes of chloroform to* 100 *litres* of air, the animal remains conscious throughout the experiment, which I have prolonged in one case to 9½ hours' duration. Temperature fell to 35° Centigrade.

"6 gr. to 100 lit.—Death supervened after about 7½ hours, with a temperature of 31°; sensibility was not lost though enfeebled, especially at the last.

"8 gr. to 100 lit.—Death took place at the end of 8 hours, the temperature was down to 30° towards the end, insensibility of the skin and cornea were observed, but appearing slowly, and after a phase of agitation.

"10 gr. to 100 lit.—The scene changes, insensibility appears in a few minutes, sleep is absolutely calm, death takes place at the end of 2 or 2½ hours without any convulsion and with a temperature of 35°–33°.

"12 gr. to 100 lit.—Insensibility still more rapidly effected, death in an hour and a quarter, temperature 35° Centigrade.

"14 or 16 gr. to 100 lit.—Death in three quarters of an hour, temperature 38°.

"18 or 20 gr. to 100 lit. Death in half hour.

"30 gr. to 100 lit.—Death in a few minutes."

M. Bert then enumerates certain facts to which he calls special attention.

A. Whether death supervenes quickly or slowly, the heart continues to beat after the respiratory movements have stopped. There never was a case of cardiac syncope.

B. Even after several hours' anæsthesia, no chloroform was ever passed in the urine.

C. With very weak doses one may cause an enormous quantity of chloroform to pass through the lungs, without obtaining any objective phenomena other than the lowering of the temperature.

D. With slightly stronger doses, death supervenes slowly, accompanied by a considerable fall of temperature, but sensibility is not lost. Therefore, given in such doses, chloroform only affects the functions of nutrition, in all probability by deadening the anatomical elements.

E. With stronger doses, although insensibility is plainly established, death always ensues if the respiration of the mixture be continuously maintained. The richer these mixtures are in chloroform, the more rapidly does death supervene, and the less apparent is the fall of temperature.

M. Bert, after promising the result of some fresh studies at a future séance, proceeds to make some practical deductions from the foregoing statements. He found that the respiration of the mixture always ends in death sooner or later.

With strong doses, 10 gr. to 100 lit., for instance, death is rapid; with weak doses death is slow, but sensibility is only very slightly dulled. He then determined to administer the doses one after the other; thus he made a dog breathe an atmosphere of 12–100 for a few minutes till he was quite insensible, and then changed the dose for 8–100. This latter strength, which, had it been employed from the commencement, would have taken a very long while to produce anæsthesia, and would, moreover, have been accompanied by considerable excitement, is amply sufficient to continue the anæsthesia produced by the stronger dose, the result being as satisfactory without any danger or any interference with the functions of respiration or circulation. The temperature had fallen and the usual unpleasant after-effects were observed.

In 1884 M. Bert again discussed the matter before the Academy; his apparatus was very severely criticised, but the main principle of an exact fixed dose was generally approved, and the value of his experiments appreciated.

A surgeon named Payrand read before the "Société de la Biologie" an account of a method of administration which consists of covering the face with a light compress, and then dropping *a single*

drop of chloroform upon it, followed after an interval of a minute or so by another; this plan is much approved by M. Bert.

The general result of all these experiments, from the days of Snow down to now, seems to point to the fact that there is little or no danger of cardiac syncope during the careful administration of chloroform, still there *are* dangers, for many deaths have been recorded. To complete the case then, it will be as well to discuss the sources to which most of these deaths can be traced.

The first element of danger is fright on the part of the patient, previous to undergoing the operation. A case is mentioned by Snow in which a patient died of fright during a *make-believe* administration of chloroform.*

The second danger is that of shock conveyed to the heart owing to insufficient anæsthesia. This, together with Dr. Brunton's physiological explanation of it, has already been fully discussed at page 21. In illustration of this danger a case may be quoted, mentioned by Lister (Holmes' Syst., vol. 3, p. 600). A gentleman had to undergo a slight and momentary operation; chloroform was given, but purposely *not fully;* the pulse was good before the knife was used; the operation was instantaneous; but at the moment of cutting the patient started, and immediately after the pulse had ceased, the heart stopped, and the patient was dead. Possibly a full dose of chloroform might have obviated this

* See note H., Appendix, page 93.

unhappy result. As far back as 1853 a Liverpool surgeon (Bickersteth) recorded the fact, that on three occasions, during an amputation through the thigh, the pulse stopped suddenly at the moment the knife entered the limb, but recovered itself after a few seconds. In all probability the dose was insufficient in all these cases.

The next danger is a very grave one; it is the administration of too strong a mixture of chloroform and air. This may be done in many ways, the most frequent being one which has been very well explained by Mr. Braine. He noticed that a large proportion of deaths under chloroform took place just after the addition of a fresh quantity of the anæsthetic, and he accounts for this fact as follows. When the facepiece is removed, that the chloroform may be added, the stimulus of the fresh air causes a deeper breath to be taken, and this is followed by still deeper ones. When the facepiece is replaced a deep inspiration is taken, and with it a sudden extra dose of chloroform. This may be obviated by replacing the facepiece gradually, keeping it some inches from the face at first, or by adding the fresh dose without removing the facepiece. Chloroform beyond a certain strength is very dangerous; below it, almost free from danger. This danger of too strong a dose is a danger special to chloroform. There are some others which are shared by all anæsthetics. One of these is idiosyncrasy of the patient, a rather obscure condition, and one very difficult to explain. The patient may be over sus-

ceptible to the effects of the vapour, but the danger of such a case would attach only to the use of some such apparatus as that devised by M. Bert, where the amount of the anæsthetic cannot be regulated to suit the emergency, but is fixed beforehand, and the judgment and tact of the anæsthetist are not able to protect the patient. This was pointed out as a defect by M. Gonelin, and is a serious objection to M. Bert's apparatus, as at present contrived.

Lastly, many deaths have been due to an omission of some of the precautions laid down in the chapter on nitrous oxide.

From all these considerations it may be gathered that chloroform is not specially dangerous unless given in too strong a dose, i.e. mixed with too little air, when it may suddenly depress the heart; or unless the operation be commenced before insensibility is complete, when the heart will very likely stop altogether. And, finally, that in common with all anæsthetics, it becomes dangerous if the ordinary precautions laid down are neglected.

CHAPTER VII.

Physiology of Anæsthesia.

The condition of an individual under the full influence of an anæsthetic, that is, the real state of his faculties and the phenomena that he himself experiences during the operation, affords some interesting problems for our consideration, that will well repay a careful investigation. It has been suggested that an anæsthetised person is aware *at the moment* of the pain inflicted, but forgets it instantly, and it is very important to demonstrate the obvious untenability of this proposition. The dread of suffering while unable to protest or explain might well terrify bolder people than the average patient; it cannot, therefore, be labour lost to demonstrate beyond the possibility of doubt, that the power of appreciating pain is one of the very first faculties to be overpowered by the anæsthetic, and that the mental condition of a person fully anæsthetised is one of total absence of thought and feeling. During the induction of anæsthesia, while the faculties are being stupefied one by one, in regular order, and again during recovery, as one

by one the great nervous centres awake and resume their sway, there may be dreams and blunted sensations, and very definite struggles, but these do not take place while the anæsthesia is complete. Not only is this enquiry into the mental state of the patient easily prosecuted, but it is a matter of primary importance, that the exact nature of the suspension of the faculties induced by the use of anæsthetics should be understood, and, moreover, that the exact order in which the functional activity of the nervous centres is abrogated, should be fully and clearly established. I trust I shall be absolved by the reader for inflicting upon him a slight preliminary sketch of the functions of certain nervous centres, in order that the phenomena attending the temporary sleep of any, or all of them, may be better described.

The characteristic functions of the central nervous organs are threefold.

1. *Reflex acts*, or the transmission of the effects of stimulation from afferent to efferent nerve fibres, that is the excitement of some motor fibres in response to a stimulus received by some sensory fibres; as, for instance, when the surface of the body is pricked with a pin, information of the fact is conveyed to the sensory nerve centre by sensory (afferent) fibres, then passed on to the motor centre, and there translated into a stimulus which induces the motor (efferent) fibres to cause certain muscles to contract and remove the injured part from the danger; this is illustrated by the closing of the eye-

lids when the conjunctiva is touched. It is important to remember that the central organ where this reflection of the stimulus takes place is not in most cases situated in the brain proper, for reflex actions may be perfectly performed when the great centres of volition and thought are paralysed and even removed; thus a frog after his head is cut off has presumably lost the power of appreciating or avoiding pain, yet if a drop of acid be placed on one leg, he will rub it off with the other because the action has become habitual, and is performed by the spinal tract without any reference to the brain. Again, the act of winking was originally performed deliberately to protect the eye, but it has become so habitual an act that it takes place without the interference of the cerebral centres; in fact, before our higher senses are conscious of the approach of danger a reflex act has already protected the eye from its consequences; the instantaneous wink takes place without the sanction of our brain proper, and even in defiance of a determination to prevent it. When it is known that there is no danger, a friendly hand rapidly approaching the face will cause most people to wink in spite of a firm resolution to keep the eye wide open. Professor Darwin tried to keep his face still in front of the glass cage of a puff-adder while the reptile struck at him, but as soon as it did strike, he involuntarily jumped away, notwithstanding his resolution to remain still.*

* The movement of the limbs in walking is continued while the brain is quite occupied with other matters, and has even

Reflex actions are orderly up to a certain point, and are directed to the removal of some definite irritation, or at any rate in response to some definite stimulus; if, however, the stimulus be exaggerated, the reflex action may become disorderly or convulsive, and result in spasm of all the muscles. The great point of importance to the present subject, established by experiment with regard to reflex action, is this, that movements of a definite kind in direct response to stimuli, do not show that the individual is conscious of the stimulus, but only that the reflex functions are not yet paralysed.

2. *Automatic acts*, which depend on an excitation of the efferent nerve, without any previous stimulus

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been continued during sleep, for soldiers have been known to fall asleep while marching. Trousseau relates some very complicated acts performed during a complete epileptic suspension of brain influence. It is plain, then, that when the powers of consciousness, volition, and thought are in abeyance, complicated acts, apparently requiring their guidance, may, if habitual, be perfectly performed by reflex action, although if not habitual they cannot be so performed; secondly, that such acts are continually performed while the intellectual faculties are fully occupied with something else; thirdly, that such reflex acts, being often more rapid and powerful than designed acts, may literally take the intelligence by surprise, and perform themselves in defiance of the strongest efforts of the brain power to prevent them (Cf. The act of starting, winking, etc.); and fourthly, that in the lower animals they can be performed after removal of the brain proper.

These facts, therefore, clearly demonstrate that although a patient may move, or even struggle slightly during an operation, this movement is not any proof that pain is felt.

conveyed by an afferent nerve, the whole thing originating at the nerve centre.

3. *Psychical acts*, acts devised by the intelligence.

The principal functions of the nerve centres are the following:—

The functions of the spinal cord, which are chiefly reflex and conducting. All impressions reaching the sensorium from the limbs must travel viâ the spinal cord; if, therefore, its functional activity be suspended, reflex action of the limbs and the conduction of impressions from the limbs to the brain are abolished.

The functions of the medulla oblongata, which are of a fourfold nature.

(1.) *The first is that it contains the centre of involuntary respiratory movements*, the so-called "vital spot" or "nœud vital," a limited portion of the floor of the fourth ventricle at the apex of the calamus scriptorius. It is on both sides of the middle line, and injury to either side arrests respiration on that side, while injury to both sides abruptly stops the function, and death ensues.

The activity of this centre depends upon certain essentials.

(*a.*) The presence of oxygenated blood, without which its irritability disappears.

(*b.*) A certain relationship among the gases of the blood, which relationship acts as a stimulus to the centre. The less oxygen there is in the blood and the more carbonic acid gas, the more intense becomes the action of this centre, until breathing becomes

rapid and gasping; the extraordinary muscles of respiration are stimulated, and at last an absolute convulsion takes place, owing to general muscular spasm. These phenomena are called dyspnœa. On the other hand, if the supply of carbonic acid gas be reduced below a certain point, the activity of the centre diminishes, and death from apnœa results.

(2.) *The second is the control of the heart's action.* The centre for the vagus, the inhibitory nerve of the heart (and some think the sympathetic or accelleratory centre as well) is in the medulla, as also the vasomotor centre by which the calibre of the small arteries is controlled, also the centre for dilatation of the pupil (the radiating fibres of the iris being supplied by the sympathetic).

(3.) *The third is that it contains the centre for deglutition.* If during the deepest anæsthesia the back of the fauces be touched deglutition at once takes place, a very useful act when it is necessary that mucus should be swallowed by an unconscious patient.

(4.) *And the fourth is the centre for mastication and sucking.*

The functions of the cerebellum. This has long been a field of dispute among physiologists, but it is pretty certain that the only important one is that of co-ordinating the action of the two sides of the body. Paralysis of the cerebellum produces a condition very like drunkenness; the two halves of the body do not work together, but act independently of each other, and the result is that the legs

produce an unsteady gait, the eyes present a double image, and the tongue utters an indistinct speech.

The functions of the ganglia at the base of the brain, which are of a twofold character.

(1.) *The first is to inhibit reflex action.* When this restraining influence is removed, reflex action becomes much more powerful and violent.

(2.) *The second is to adjust equilibrium.* If the ganglia on one side be injured or removed, unusual and uncontrollable movements are executed, such as rapid rotation of the body, which is no doubt due to a sensation of vertigo and a consequent delusion as to the movements of surrounding objects. The true position of objects is appreciated by means of eyesight, and if we alter our position the object appears to do so too; thus, if the object seem to move we move also, under the impression that we are thereby keeping still, hence a movement in the opposite direction, either of the head and body, or of the eyes alone. Now, if an electric current be passed through the base of the brain from left to right, the poles being placed on the mastoid processes, the objects within the field of vision appear to revolve in the direction of the hands of a clock, and therefore an attempt is made to counteract the imaginary movement by an actual movement of the eyes and even of the body in the opposite direction.

The functions of the cortex of the brain. The cortex is the seat of thought, consciousness, and volition; in short, of all the higher attributes of the animal.

These facts have been demonstrated mainly by—

(*a.*) Comparisons of the attributes of various animals and the development of their nerve centres.

(*b.*) Investigations of the attributes of animals congenitally defective in portions of the nervous system.

(*c.*) Observations of the losses inflicted by definite lesions of injury or disease upon the nerve centres.

(*d.*) Artificial infliction of cerebral imperfections, such as the experimental removal of portions of the brain substance.

By these and other means the foregoing facts have been demonstrated to be true.

A reflex act, however orderly, must immediately follow the stimulus that causes it. A psychical act, on the contrary, may be the result of stimulus received long before. The storage of this stimulus is "memory." In all probability no stimulus is ever lost, nothing is ever really forgotten, and the most trifling incidents of the distant past are often faithfully revived in dreams, while the repetition at another time and place of some associated stimulus, such as a peculiar scent or sound, will often reproduce faces and words and scenes of long ago that we fancied had faded altogether from our minds. These revivals are very capricious. So much so that it is not the things most familiar to the mind which are the easiest to revive, but on the contrary, those that cause a strong impression by their strangeness. Thus it has happened that during delirium the

ravings of innocent, pure-minded persons have taken the form of expressions quite foreign to their nature, not because they were in any way familiar, but because heard accidentally, the very strange and unfamiliar sounds had, without their knowing it, made a strong impression upon their brain unknown to themselves.

It is very important to recollect that the higher centres of the brain exercise a restraining and controlling influence over the reflex actions, for, as we shall see, there is a brief period during anæsthesia when these controlling centres are paralysed, but the reflex power remains active, and under these circumstances the struggles and muscular efforts of a reflex nature are more powerful than they would be were the senses unimpaired and the effort or struggle performed deliberately.

At such a moment a little child will sometimes effect movements that strong men will find a difficulty in restraining, and the convulsions of an adult, whose cerebral control is suspended either by delirium or during incipient anæsthesia, often display an amount of force altogether disproportionate to the apparent physique of the individual.

It is, therefore, to be expected that, as each of the nervous functions becomes overpowered by the anæsthetic, the individual will behave as if he did not possess that particular portion of his nervous system.

The first function paralysed is that of the ganglia of the base of the brain; objects seem to swim round and round, and giddiness super-

venes. Then the cerebellum and the cortex of the cerebrum are involved and co-ordination is lost, and the faculties of will, memory, consciousness, and thought are stupefied. At this stage reflex power is still perfect, and though the patient will make definite struggles, and even cry out if hurt, he is not conscious of the injury, nor will he remember it; his lids still wink when his conjunctiva is touched, but he does not know that it has been touched; a step further and the sensory centres are involved, he no longer possesses reflex but only automatic action, that is, he may struggle and shout, but his movements have no connection with injuries inflicted, or he may struggle when they are not inflicted, and remain passive when they are, because no message of injury is conveyed from the sensory nerve endings to the centres; if the conjunctiva is touched, the lids do not move in consequence, though they may wink, and any other movement may be performed independently of any injury received. Next in order the motor centres are affected, and there is no power of movement save such as may have its origin in the medulla (respiration, deglutition, and the action of the heart are still in full reflex working order); if asphyxia be induced, the extraordinary muscles of respiration will be called into play; if the fauces be tickled deglutition will be performed. Suppose the anæsthetic be pushed, respiration and the heart's beat will continue, but they will not be affected by external stimuli; a stage further and the motor

centres of the medulla will be paralysed and death will ensue. The order of recovery is the exact inverse of the order of paralysis, and during recovery there is a stage when the reflex actions of the system have revived, and definite struggles follow definite injuries. If the pain produced by the operation be prolonged till the awakening of the powers of memory, the patient's dreams will be affected, and the patient, who will probably think he has felt the whole operation, will find himself struggling, while the rapid energies of fancy will fill up the picture. On one occasion in which the gag slipped, and nothing was done save an ineffectual attempt to open the mouth, the patient awoke, thinking she had felt the whole operation, *although no operation had taken place.*

On another occasion the well-directed efforts of the patient to seize the forceps caused the operator to desist, and after a few moments' silence, the patient awoke, utterly ignorant of the fact that he had struggled at all.

During the few brief instants of recovery of cerebral power, very exact dreams may be formed from very small exciting causes. The prepossession just before becoming unconscious, that something is about to happen—say the extraction of a tooth, or even a casual word during recovery coupled with the removal of the gag—is quite sufficient for the patient's fancy to build upon. It has been abundantly proved that hardly any time is requisite for long and circumstantial waking dreams to be

elaborated, and the only secret for avoiding this is not to interfere at all with the patient during the interval between the recovery of reflex power and the awakening of the intelligence. It is during this interval that the patient's "recollections" of the operation are formed, and it is partly upon the operator's abstinence from interference at this juncture, that his own fame and that of the anæsthetic depend.

The stages of anæsthesia may be tabulated thus:

1. *Stage of giddiness.* The ganglia of the base partly affected, volition and thought deranged, hearing acute, reflex action perfect, innervation of heart complete (inhibitory "vagus" and accelerator "sympathetic" unaffected); pain inflicted now will produce violent struggles, cause excited fancies, and arouse the patient.

2. *Stage of incipient anæsthesia.* Cortex, ganglia at the base, and cerebellum paralysed, i.e. volition, thought, consciousness, and co-ordination lost, sympathetic (acceleratory) nerve to heart paralysed, inhibitory vagus intact, reflex action intact; an injury now may stop the heart's action, and will probably produce very violent struggles; but if desisted from the patient will not remember the struggle on recovering.

3. *Stage of sensory paralysis.* Reflex action is lost because the sensory system can no longer convey the stimulus, and as the injury will not, therefore, be communicated to the vagus, the heart will not be affected. There may be struggles, twitchings of

the extremities, rhythmical movements, noises, &c., but these are not in any relation to injury inflicted, but are independent of it.

4. *Stage of total paralysis*, of everything except the essential centres of the medulla. The only movements now are those of respiration and of the heart's action. Beyond this stage death ensues.

The process of recovery is a simple reversal of these four stages; the struggles and twitchings re-commence; the vagus and sympathetic nerves recover their powers; one by one the faculties of life awake, until the whole animal economy is restored to perfect working order. During this revival the several stages, with their special conditions of the nervous system, are precisely similar to those into which I have subdivided the production of anæsthesia (save that they occur in the reverse order), and the same precautions must be observed in each stage.

It remains to be stated, in this connection, that our knowledge of the physiological action of anæsthetics is sadly deficient in one important direction. We have only very imperfect data to go upon, as regards the condition of the cerebral vessels, during the exhibition of various anæsthetic agents. For instance, in the case of chloroform and ether, the vascular condition has been observed to differ to such an extent, that our choice of these agents, for particular cases, would be very seriously modified were we practically acquainted with the true cause.

The facts at present in our possession are, briefly stated, the following:—

1. If the supply of blood to the brain be arrested, from whatever cause, anæsthesia will be one of the results (anæsthesia due to anæmia).

2. If, on the other hand, the escape of blood from the brain be in any way impeded anæsthesia will be a consequence of this condition (anæsthesia due to hyperæmia).

3. If the quantity of the blood supplied to the brain remain unchanged, but its nature be so altered that it is no longer capable of nutrifying the brain tissue, anæsthesia will ensue.

4. Any considerable alteration in the vascular condition of the brain is attended by anæsthesia.

5. Lastly, it has been possible in many cases to observe the vascular condition of the brain during sleep, during anæsthesia arising from shock, and during anæsthesia produced by the inhalation of anæsthetics, in individuals whose brain surface has been accidentally exposed to view; and the result of these observations has been to show that a vascular change always accompanies such anæsthesia. Professor Carpenter, in his 'Mental Physiology,' 1876, p. 572, strongly inclines to the view that the anæsthesia accompanying sleep is dependent upon "a reduction of the enormous blood supply which is essential to the functional activity of the brain, and that this reduction is effected by the control which the vaso-motor system of nerves has over the calibre of the arteries." On the same page he quotes an

experiment in which Dr. A. Fleming produced a condition closely resembling sleep by compression of the carotid.

Sleep which is the most natural and free from risk of all the anæsthetic states is attended with (and probably caused by) a diminution of blood pressure in the brain, consequent on a contraction of the small arterioles under the influence of the vaso-motor or sympathetic nerves.

Let us now consider an experiment quoted by Dr. Carpenter from 'Guy's Hospital Reports,' 1860, p. 153:

"In the experimental enquiries of Mr. A. Durham, made by removing (under chloroform) a portion of the skull of a dog, so as to expose the cortical layer of the cerebrum, it was observed that as the effects of the chloroform passed off, and the animal sank into a natural sleep, the surface of the brain, which had previously been tinged with blood and inclined to rise into the opening through the bone, became pale, and sank below its level. On the animal being roused after a time a blush seemed to start over the surface of the brain, which again rose into the opening through the bone. And as the animal was more and more excited, the brain surface became more and more tinged with blood, numerous vessels which were invisible during the sleep being now conspicuous, and those before visible being greatly distended. After a short time the animal was fed; and when it again sank into repose these vessels contracted again, and the surface of the brain became as pale as before."

Here, then, two anæsthetic states are observed, the one due to chloroform accompained by cerebral hyperæmia, the other that of sleep, an anæmic state —but we do not know how the chloroform was given, what strength, what quantity—and the absence of these facts robs the statement of much of its value.

It has been stated that the anæsthesia of ether is not accompanied by the same amount of cerebral congestion that is supposed to attend the condition when induced by chloroform; but without fuller data, and an exact description of the method of inhalation, the statement cannot be of much service, except to show what an important matter we are ignorant of for want of a little experimentation. The importance of the point as affecting the safety of patients while under anæsthetics is very self-evident. A state of extreme cerebral congestion is a state of imminent peril to life. If the cerebral vessels are unsound, atheromatous or calcareous, the danger of overstraining them cannot be over-estimated; if, then, it could be shown that any agent was more liable to expose the patient to this risk than another, by judicious selection, the anæsthetist might save a certain number of lives per annum. In this country, however, the preservation of *human* health and life does not command sufficient interest, among those who make our laws, to protect scientific investigators from the energy and zeal with which fanatics, hysterics, and people in search of new sentimental excitement pursue their crusade against

the promotion of knowledge. There are happily still other countries where research in this branch of science is permitted, and it is therefore probable that further light will be thrown upon this point by some foreign observer.

NOTE A.

Duties of the Operator.

A few points remain to be considered which, while they cannot be said to fall exactly within the scope of the title of this little book, may without irrelevancy be touched upon in an appendix.

First and foremost, I have some advice to offer concerning the duties of the operating surgeon while the anæsthetic is being administered, my only apology for the apparent impertinence of such advice being, that I am assured by more than one leading anæsthetist that much inconvenience frequently arises from the disregard of a few simple, but important rules.

The operating surgeon should never by word or action interfere with the administration of the anæsthetic. It is the province of the anæsthetist to produce a safe and thorough anæsthesia; to do this well he must be undisturbed by hints or questions. The operator has nothing to do with the pulse or the heart, or anything—save the operation. Having assured himself that he has room to operate, that the gag is where he desires it to be, and that the patient is in the most suitable position, he has nothing to do but to keep quiet, and be ready for the administrator's signal.

I may enforce the importance of this advice by quoting

a case or two, for the facts of some of which I have the authority of my friend, Mr. Bailey. In one case the gas had to be administered twice, because the nervousness of the surgeon induced him to repeatedly implore the anæsthetist not to give too much, thereby exciting the patient with groundless fears and flurrying the administrator. In another case an injudicious argument between the surgeons suddenly interrupted the anæsthesia, and awakened the patient, who jumped up, excited by the ether, to *join the discussion.*

I myself remember an old medical friend, for whom I extracted a tooth under gas, telling me afterwards, that just as he was becoming insensible he was half roused to consciousness by an incautious remark that I made, and consequently the anæsthesia was considerably delayed. On one occasion at the Dental Hospital the extractor asked the question "Are you ready?" when the patient was only half under the influence, and the result was a terrific struggle on his part. He was a powerful man addicted to alcohol. The excitement lasted several minutes, and if he had succeeded in freeing himself, some one might have been injured.

Mr. Bailey and Mr. Bird have both often assured me that there is no greater mistake than to fasten a patient to the chair, or to clutch at him unnecessarily; either is sure to provoke struggling. Mr. Bailey prefers not to restrain even swinging of the arms and legs, provided there is no risk of injury to the patient or bystanders. Such movements usually subside of themselves, but if they do not it is better to tell the patient gently to keep still than to use any force.

In arranging the attitude of the patient, it is well to remember that the head should be as nearly as possible in a straight line with the axis of the body, neither bent backwards nor forwards. This is essential to free breathing, a fact very easy to demonstrate by sitting in a chair

and assuming the various attitudes, and observing the comparative facility or difficulty of breathing. In this connection it is well to point out another mistake, frequently made by operators who use hawks-bill instruments for lower molars, namely, that of pushing the tongue backwards with the left hand, and thereby often shutting off the respiratory tract altogether; in the eagerness of extraction, the danger of pushing the tongue too far back is often forgotten. This error should be carefully avoided, for the results may be very unpleasant should the operation be protracted by any misadventure.

At the same time it is of course very right to interpose a finger to avoid the tongue being wounded by the forceps, because such an accident is always distressing to the patient after the operation.

I must confess to a certain scepticism with regard to the usefulness, in practice, of spoons for protecting the tongue or the larynx. The ingenuity of their construction is unquestionable; but the presence of a gag and a spoon in the mouth leave but little room for the operator. Moreover, there is a certain loss of time attending the application of such apparatus; perhaps, however, the question resolves itself into this: different operators will incline to different methods to protect their patients, and the personal skill of each will render his method the best *in his own hands.*

Idiosyncrasy (see page 37). I have made very careful enquiries on this point in order to discover, if possible, what ground there is for asserting that certain individuals are readily susceptible to the influence of Nitrous Oxide Gas, while others are the reverse; and I have been forced to the satisfactory conclusion that there is practically no such thing as idiosyncrasy.

There are isolated cases from time to time in which patients are an inexplicably long time in becoming insensible; but the longest time in Mr. Bailey's experience

is two minutes twenty seconds, while Mr. Bird does not recollect any case of a patient remaining conscious more than one minute, unless by chance or design air has been mixed with the gas.

The time usually required to produce anæsthesia with pure Nitrous Oxide is not inconvenient to any one; but the same cannot be said of any given mixture of gas and air, and this, as suggested by Mr. Bird (see page 36), possibly forms one of the chief obstacles to M. Bert's method.

Dr. Snow does not attach any importance to the question of idiosyncrasy.

NOTE B.

Artificial Respiration and Syncope.

When the movements of respiration have ceased, there is no longer a rhythmical entrance and exit of air to and from the lungs, and consequently the blood is not aërated.

If, however, the chest walls can by artificial means be made to contract and expand rhythmically, the tide of oxygen to and fro may be maintained until the natural chest-movements revive. This is effected by producing an alternate expansion and contraction of the thorax, the expansion causing a vacuum inside, and sucking in air to fill it, which air is again expelled by the contraction.

The increase of the size of the thorax is caused by the ribs being moved outwards and upwards, their ends being fixed. As each rib represents, roughly speaking, a half circle, it is easy to understand that while one end is attached to the spine, and the other to the sternum, an upward movement of them all must cause an increase of the thoracic space. If the arms are raised above the head, they (by means of the pectorals) pull the ribs upwards, while if they are lowered and pressed against the side of the chest they push the ribs downwards. This is the salient principle of artificial respiration.

I quote the following account of the "Sylvester" method from Holmes' 'System of Surgery,' vol. iii., from the excellent article by Mr. Harley.

"Manual pressure equal to about thirty pounds may be with perfect safety applied to a healthy adult human thorax.

"In making the pressure, care is to be taken to observe if any food is forced out of the stomach, which may happen if that viscus is full; and, if so, it is necessary to prevent it getting into the windpipe. This may be readily done by placing the patient for a few seconds on his face and forcibly expelling the food by pressure on the back.

"The manual pressure ought to be made on the lower part of the sternum, for the resilience of the thoracic walls is there greatest; and pressure on the abdomen at the same time is not to be omitted or the diaphragm will descend and counteract the benefits derived from the pressure made on the lower part of the chest.

"*The Sylvester method of artificial respiration*, which is by far the most effectual mode of obtaining an interchange of the pulmonary gases, is performed by alternately raising and depressing the arms, as exemplified in the figs. 1, 2, on pages 80 and 81, which themselves describe the mode of procedure more plainly than words can. As is observed in the figure, the patient's shoulders are not only well raised, but his head (as Dr. Howard suggested) thrown well back. On bringing down the patient's arms they should be gently and firmly pressed against the sides of the chest, so as still further to diminish the cavity of the thorax. This pressure can be exercised with greater facility and equal effect by pressing the arms on the lower third of the sternum. By alternating the movements of the arms and pressure of this kind, a regular exchange of air can be produced, varying in quantity from thirty to fifty cubic inches, an amount more than is requisite for the purposes of resuscitation.

"If there be sufficient assistance at hand, the Sylvester method ought to be employed in all cases in which

artificial respiration is considered necessary; but where the medical attendant is alone, simple manual pressure is the quickest and easiest that can be adopted. It only differs from the Sylvester method in this respect, that in it the air is forcibly expelled from the lungs and then allowed to enter, in consequence of the vacuum produced in the thorax by the re-expanding of the walls by their own elasticity, while in Sylvester's method the air is forcibly inhaled and expelled by raising and depressing the ribs. In both cases the respirations should amount to at least thirty or even forty per minute. The natural respirations are only eighteen per minute, but in cases of resuscitation, as our object is to arterialise the blood even more rapidly than in health, and as we cannot introduce by artificial means the same amount of air that is taken in by the normal efforts, we must proportionally increase the number of respirations."—Holmes' Syst., vol. iii. p. 837.

The Howard method, which is a modification of Sylvester's, was, I believe, described at a meeting of the Odontological Society by Dr. Howard.

The illustration, Fig. 3 on page 82, gives such a clear and comprehensive idea of it, that but little description is necessary. From the engraving it will be observed that the operator places one knee on the thorax of the patient. This enables him to compress the thorax at the same time as he moves the arms, thus saving fatigue, and doubling the efficiency of his exertions.

While speaking of artificial respiration, it will not seem irrelevant to add a word of two about syncope. People who are given to fainting are liable to do so in the operating-room just as much as elsewhere, but the accident has no significance; it is, however, important that any person in a fainting fit should be promptly laid flat on the back, with the head if possible lower than the shoulders. This position is sufficient as a rule to restore consciousness

in a few seconds. An inclination to faint may, while in the operating chair, be checked by pushing the head forwards and downwards between the knees. A drop or two of sal-volatile in water, or better still, if available, a sniff at a capsule of nitrite of amyl, will restore the patient at once. These capsules and instructions how to use them may be obtained at Martindale's, in Cavendish Street, or at Ash's, in Broad Street; but of all restoratives the best is the prostrate position. This fact should, in my opinion, be printed in large letters at the entrance of every church and every theatre, and taught to every child in the nursery. A person with a weak heart in a fainting condition, held up and sometimes hugged tight by well-meaning friends armed with scent and luke-warm water, is within a measurable distance of being fondled lovingly out of this life altogether, yet how frequent a spectacle it is—the anxious friend sedulously stopping the heart's action, the curious and kindly circle shutting off the air, or at any rate rendering it warm, stuffy, and impure, and the officious bystander, with a handkerchief reeking with scent, poisoning what little air does reach the patient. With such a scene before my mind's eye, I feel excused for urging this point of the position of a fainting person.

It is sometimes necessary to maintain the prone position for some little time to allow the heart fairly to recover. On one occasion a patient fainted, owing to the heat in the stopping-room at the top of the Dental Hospital building in Leicester Square. She was laid down on her back and instantly recovered, but on attempting to rise, fainted again; this condition of consciousness while lying down, and instant relapse on sitting up, continuing for some time.

The dental practitioner when operating with an anæsthetic is not unfrequently puzzled by phenomena that are due to hysteria. Snow mentions a few cases of prolonged anæsthesia and inability or disinclination to rouse. Some years ago a girl gave some anxiety to the house

surgeon at the Dental Hospital by remaining in a lethargic state, until the late Mr. Clover suggested that it was owing to her having taken too much brandy that morning, when she at once jumped up and indignantly denied the charge, to the amusement and relief of the bystanders.

Quite recently a youth of about eighteen, apparently a foreigner, to whom Mr. Bird had given gas, displayed very curious symptoms of hysteria. He partly recovered from the anæsthetic, and then suddenly had a kind of spurious fit, during which he struggled so violently that three of us had some trouble to prevent him hurting himself. He half recovered and cried, and said he could not help it, and again relapsed into a fit; this occurred three or four times in succession.

The most common freak of hysterical patients is to pretend that they cannot rouse themselves, and this may well alarm a young practitioner; he may, however, rest assured, if the breathing is regular, that there is no kind of danger, seeing that a minute or two suffices to get rid of every trace of nitrous oxide from the system.

When fainting does occur after an anæsthetic, it is not unfrequently due to the excessive zeal of the medical man which leads him to order a long fast beforehand. As has already been said (see quot. from Braine, p. 10), the danger of faintness is greater than the danger of sickness, and it is always better to time the operation, so that the stomach is empty without any special abstaining from food. In fact, throughout the operation much of the success depends upon the absence of *special* conditions altogether, for special instructions, special diet, anxious questions and examinations all tend to create a fluster and to excite and disturb the patient; whereas, on the other hand, the apparent absence of precautions, paraphernalia, anxious enquiring glances, and mysterious hints between the operator and the anæsthetist, suggest to the patient that there is really nothing to make a fuss

about. The room should be as like an ordinary sitting-room, and the chair as like an ordinary armchair as possible, and there should be no instruments visible. If the patient be a woman or a child, the presence of a woman servant is always pleasant and reassuring, and the absence of the friends of the patient contributes much to the ease of the operator, and the success of the operation.

FIG. 1. INSPIRATION.—SYLVESTER'S METHOD.

FIG. 2.—EXPIRATION—SYLVESTER'S METHOD.

FIG. 3.—HOWARD'S METHOD.

NOTE C.

SOME CASES OF AFFECTION OF THE PULSE EXPLAINED.

"A PECULIAR and interesting fact, and one that I am inclined to think may account for many deaths, is, that in some individuals when fully under the influence of chloroform the pulse suddenly fails at the moment the first incision is made by the surgeon, and this, too, when the respiration is altogether natural. The first time I observed this peculiarity was in Oct. 1851; the subject was a sickly emaciated boy about nine, requiring amputation of the thigh on account of an exhausting disease of the tibia. He was quickly brought under the influence of chloroform, and was breathing well when Mr. Syme transfixed the limb. I had my hand on the pulse, and was carefully watching it. At the moment the knife entered it suddenly ceased, and remained imperceptible for a period of four or five pulsations, the countenance at the same time becoming deadly pale. As it returned it was at first very feeble, but in a few seconds it regained its usual strength. The breathing at the same time was very soft and quiet. Anæsthesia was maintained, and no further untoward event occurred."

"The next case was that of a young lady about eighteen or twenty years of age, whose thigh Mr. Syme amputated in November last. Dr. Simpson administered the chloroform, and after the operation remarked that the pulse had

stopped suddenly just as the knife was piercing the thigh, and had recovered itself with a flutter almost immediately."

"A third instance occurred soon afterwards on the 10th of December, 1851. A woman about forty, of pale emaciated appearance and nervous excitable temperament, was placed upon the operating table and inhaled chloroform. She inhaled it well, and was soon insensible, breathing stertorously; then the operation (amputation of the thigh) was begun, and at the same instant the pulse stopped, and did not return for eight or ten seconds, when it was again felt as very faint and indistinct. It rapidly regained its force, and before another minute had elapsed, was as strong as before the operation. During this occasion the breathing did not flag at all, and had it not been for a slightly increased pallor of the countenance, no visible change might have been observed." . . . .

Citing another case, the same author says, quoting Mr. Stanley, of Bartholomew's Hospital: "A few minutes afterwards I commenced the operation by an elliptical incision through the skin, circumscribing the portion of the cheek which I intended to remove. *Directly this was done* my assistants, who were watching the pulse at the wrist, reported that it could not be felt." In this case it returned, and with its return the patient recovered.

Another case is quoted from the 'Medical Times and Gazette' for March 20, 1852. A man, twenty-three years of age, inhaled chloroform, and in a few minutes insensibility was produced (after some struggling). "The operation was then commenced, but no sooner had Mr. Lloyd cut through the skin than it was stated that the pulse had suddenly ceased."—Bickersteth, Ed. 'Monthly Journal,' 1853, vol. xvii. p. 220.

Mr. Bickersteth concludes very rightly that this stoppage of the heart was due to shock and not to chloroform; but he is puzzled by these two facts: first, that in

the case of Mr. Stanley, no syncope took place during a severe operation without chloroform; and secondly, that in Mr. Lloyd's case, a more serious operation *under chloroform*, was performed upon the patient without syncope. Dr. Lauder Brunton's observations—see p. 21—show the reason why these are not difficulties; in both cases, no doubt, only enough chloroform had been given to paralyse the acceleratory cardiac nerves, leaving the inhibitory open to stimulus.

In the following paragraph Mr. Bickersteth very strongly enunciates the doctrine, so much insisted upon by Lister in later years, that the pulse is no safe guide:

"But the pulse should not be taken as any guide during the administration of chloroform. It should be wholly disregarded, except under certain circumstances when syncope is feared from loss of blood during the performance of capital operations. The pulse is only affected secondarily in consequence of the failure of the respiration. It follows, therefore, that our attention should be mainly directed to the latter, while the former may be altogether neglected, or at any rate regarded as only of secondary importance. By carefully watching the pulse the attention must in a measure be taken away from the respiration, and exactly to such a degree it is productive of evil; for in order to guard against mishaps, and at the same time conduct the inhalation with confidence, the breathing must be observed with the greatest care and attention."

NOTE D.

SOME EXPERIMENTS TOUCHING THE QUESTION OF FAILURE OF RESPIRATION OCCURRING BEFORE THAT OF THE HEART'S ACTION.—Bickersteth, 'Month. Journ. Med. Science,' 1853, vol. xvii. p. 212.

MR. BICKERSTETH administered chloroform to three rabbits (1850), until respiration ceased altogether. When the animals had all the aspect of death, he opened the chest and observed the heart beat; this became more irregular and feeble, until, in four minutes in two cases, and in three minutes in the other, the beat ceased altogether. In another case after respiration had ceased, he opened the chest and found the heart contracting quickly and irregularly. He introduced a blowpipe into the trachea and performed artifical respiration; the heart's action became regular immediately, and remained so for twenty-five minutes when he desisted from the artificial respiration, and the heart ceased to beat in about four minutes. Thus impure air (that had already been inhaled), forced into the lungs maintained the heart's action so long as the operation was continued.

In the fourth experiment, Mr. Bickersteth put a cat under chloroform; in eight minutes complete anæsthesia was produced; in three more minutes the breathing became disturbed, and shortly ceased altogether. After waiting a minute or more to be sure of this, he opened the chest, and

placed his finger on the part of the diaphragm which is in contact with the heart, the latter was beating quickly and regularly, while the former was motionless; he then divided the trachea, introduced a tube, and performed artificial respiration with an india-rubber bag; with this the lungs were filled, and allowed to collapse by their own contractable force at the rate of about twenty respirations per minute. In four minutes the diaphragm began to descend, at first irregularly, afterwards regularly, and then movements of the head, mouth, and feet commenced, and continued for ten minutes. Air saturated with chloroform was again administered, the action of the diaphragm stopped in about four minutes, the heart continued to contract (but more quickly) for six minutes after the diaphragm had stopped, it then became irregular, and almost immediately the ventricle stopped simultaneously, the auricles still contracting slowly and irregularly, and in a few seconds, notwithstanding that pure air was substituted for the chloroform, the auricles were also tranquil.

Post-mortem examination ten minutes after death revealed the heart with both sides full, the right with dark, the left with red blood, and the lung slightly congested. This experiment shows that the heart's action continues after the respiration has stopped for about four minutes, during which time artificial respiration properly performed may restore the faculties by maintaining life until after the effects of the chloroform have passed away. In another case he restored a cat by artificial respiration after inspiration had ceased for seven minutes.

Lastly, Mr. Bickersteth quotes several cases in which these facts were put to practical proof by the employment of artificial respiration after the natural function had ceased, with the result of a restoration of the natural function even after a lapse of five minutes.

NOTE E.

TWO CASES ILLUSTRATING THE DANGER OF OMITTING TO OBSERVE THE RESPIRATION.—*See p. 5.*

LISTER (*loc. cit.*) quotes two cases of great interest as illustrating this point:—

1. "As an example of the risk that is run by want of close attention to the respiration, I may mention the following case. A surgeon of considerable experience was giving chloroform to a patient, on whom an operation was being performed, of which I was a mere spectator; but I noticed that stertorous breathing came on and gradually passed into complete obstruction at a time when the administrator was gazing with interest upon the proceedings of the operator. Seeing that the patient was in danger, I suggested to the giver of the chloroform the propriety of pulling forward the tongue. He replied that this was uncalled for, and pointed to the heavings of the chest as evidence that breathing was proceeding freely. Knowing from what had gone before that those efforts were doing nothing for the respiratory function, and feeling that there was no time for discussion, I stepped out of my province so far as to seize the tongue myself and draw it forward, when a long and loudly stertorous inspiration demonstrated the necessity for the interference. Had the delusive movements of the chest been trusted, it is probable that they might have continued till the heart had become so enfeebled by the asphyxial state as to

cause no perceptible pulse at the wrist; and had death occurred under these circumstances, the case would have been set down as one in which the circulation failed before the respiration. The administrator would thus have been absolved from all blame; and the fatal event would have been attributed to idiosyncrasy, or to any heart disease which might have been discovered on post-mortem inspection."

2. "An incident which occurred during my Glasgow incumbency illustrates so strikingly both the value of drawing forward the tongue and the relations of the circulation and respiration to chloroform, that it seems right to place it on record. One of my colleagues in the infirmary had been making an attempt to reduce a dislocation by means of the pulleys. Chloroform having been given very fully by the house surgeon, who at the close of the performance removed the cloth from the patient, and proceeded to attend to other matters. Happening to be present, and observing that the respiration was deeply stertorous, I watched it carefully and noticed that it passed almost immediately into complete obstruction, though still accompanied by the movements of the thorax, the face meanwhile becoming markedly livid. Unwilling to interfere, and seeing the carotid pulsation conspicuous in the neck, I waited awhile, hoping that the obstacle to the breathing would disappear spontaneously. But instead of this I soon saw, to my horror, the lividity give place to what I knew physiologically identical with *post-mortem pallor*. I now rushed forward and drew the tongue out firmly with the artery forceps; air at once passed into the chest, and the man was rescued."

NOTE F.

SOME CASES ILLUSTRATING THE STATEMENTS ON PAGE 29 WITH REFERENCE TO LACTATION, ETC.

"I MAY here mention the case of two patients who were suckling, and in whom the shock from the extraction of a tooth, without the gas, stopped the secretion of milk; subsequently, having to undergo a similar operation under like circumstances, they determined to take the gas, and in neither instance did any derangement of the function of lactation occur. Children with chorea, and people who have had hemiplegia, take the gas well. In phthisical patients, if the mischief be extensive, some caution is necessary; as in these cases the anæsthesia deepens after the removal of the face-piece, so that it is neither necessary nor advisable to start with any deep amount of insensibility.

"It is perfectly safe to administer this agent to epileptic patients. I have met with several cases where the extraction of a tooth, without gas, has produced an epileptic attack, but I have never seen one occur when gas has been given. A little time ago I accompanied a surgeon to a case of circumcision, on a boy, about 2½ years old. On entering the room I found the patient lying on the floor, in a very severe epileptic fit. In a short time he became partially awake, and not seeing any good reason for waiting, I anæsthetised him there and then; and, after the operation, he recovered in the usual way.

"Great age is no bar to the administration of nitrous oxide; my oldest patient, a lady, having reached the age of ninety-four."—Braine, 'Journal of British Dental Association,' Dec. 1884.

NOTE G.

Heart Disease as a Complication.

"It happened not long ago that an elderly lady, whose mammæ I removed for scirrhus, died a few days after the operation from the singular complication of perforation of the duodenum by an ulcer, caused apparently by the irritation of gall stones. She had taken the chloroform quite well, but I found on post-mortem examination that the heart was affected with as extreme a degree of fatty degeneration, and at the same time thinning of the ventricular walls, as I could well imagine to be consistent with the maintenance of circulation."—Lister, Holmes' System, vol. iii. p. 614.

Here is a case in which, had the patient died during the anæsthesia, a clear case of "heart disease" causing death would have been made out. As a matter of fact, a great deal of anxiety about heart disease in connection with anæsthetics has arisen simply enough—by throwing the blame of every death upon the heart. The existence of a weak heart is supposed to be a sufficient cause of death without further enquiry.

NOTE H.

Death from Fright.

Dr. Snow recounts a case in which the patient died of fright because the anæsthetist made a pretence of administering chloroform, that is, he had not really begun to give it, but was allowing the patient to breathe nearly pure air.

Lister quotes a case (Holmes' Syst. vol. iii. p. 600), in which "the late Dr. Richard Mackenzie, being called to see a gentleman who had fractured his radius, had some thought of employing chloroform in examining the arm, but changing his mind, made the necessary manipulations without it. He then proceeded to leave the house; but had not got down the steps leading from the door when he was called back, with the announcement that his patient had suddenly expired."

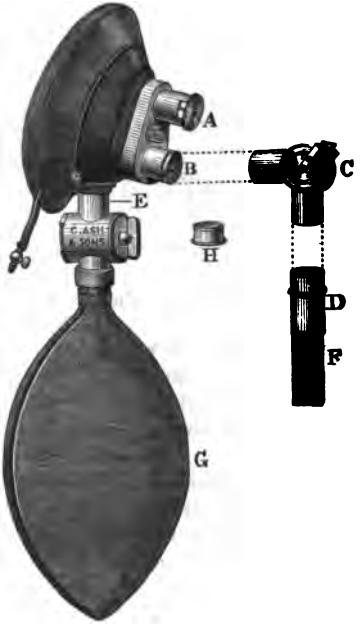


Fig. 4.

Description:

A—Expiratory Valve.
B—Inspiratory Tube.
C—Two-way Stopcock for connecting Facepiece and Cattlin's Bag.
D—Mount attached to Mohair Tubing of Cattlin's Bag.
E—Mount for holding either an Ether or a Supplemental Bag.
F—Mohair Tubing leading to Cattlin's Bag.
G—Ether Bag or Supplemental Bag.
H—Cap to cover Mount when the Ether or Supplemental Bag is not used.

This Facepiece is furnished with moveable India-rubber Pad.

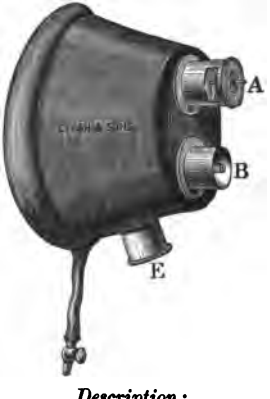
Mr. CLOVER'S FACEPIECE.

(Fig. 4.)

One great advantage of the Supplemental Bag (G) is that, while it continues to empty itself and refill, there can be no doubt that respiration is being properly performed; it is an unfailing index of the state of this all-important function. During the early stages of the administration some patients hold their breath, thereby delaying the operation, and causing great discomfort to themselves in the form of a painful sense of suffocation; this may be done almost unconsciously, but the administrator can detect it at once by the cessation of the movements of the Supplemental Bag. He should tell the patient to breathe outwards, and the inspiration will follow the expiration as a matter of course. Lastly, there is no need for alarm if the breathing appear very slow, because the time between the respirations may seem much longer than it really is. To reassure himself upon this point, the administrator need only regulate his own respirations by those of the patient, and he will probably find the apparently long intervals do not produce any particular sense of discomfort. This plan is much to be recommended, for if adhered to it ensures attention being fixed upon the patient's breathing, and thereby contributes to the absolute safety of the anæsthesia.

CONICAL FACEPIECE. (Fig. 5.)

FLEXIBLE FACEPIECE. (Fig. 6.)



Description:
A—Expiratory Valve. B—Inspiratory Tube.
E—Mount for holding either a Supplemental or an Ether Bag.
Both these Facepieces are fitted with fixed Pads.

PEDAL ATTACHMENT FOR LIQUID GAS BOTTLES (Mr. Clarkson's).

By the use of this Attachment the gas is under the entire control of the administrator, and his hands are unfettered. He is thus enabled to give his attention to the Facepiece, &c. It has also another advantage, namely: the force of the gas is broken by the Brass Pillar in its passage from the bottle to the Cattlin's Bag.

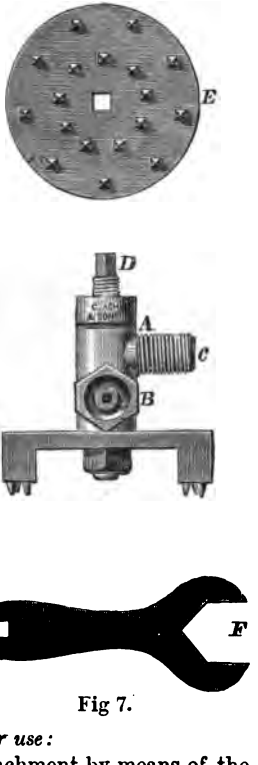


Fig 7.

Description:

A—Brass pillar with iron base.

B—Union for attaching to gas bottle.

C—Male screw to which the Cattlin's bag is fixed.

D—Tap leading to bottle.

E—Foot key for releasing the gas.

F—Spanner.

Directions for use:

Connect the bottle to the attachment by means of the union B; fit the union of the Cattlin's bag on to the male screw C; open the tap of the bottle, place the foot key on the attachment and release the gas by gently unscrewing.

Fig 8.—Gas Stand.

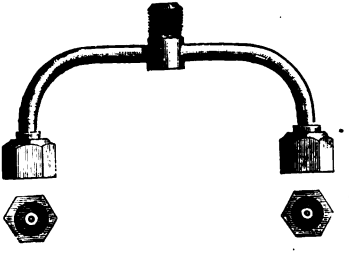


Fig. 9.—Double Union.

LIQUID GAS BOTTLE STAND.

For use in the Operating Room.

(Mr. NAPIER'S.)

Description:

This apparatus is designed to hold two bottles of Liquid Gas—which are secured in position by rings and thumb-screws—and is fitted with a Double Union, which connects both bottles with the Facepiece.

By this arrangement the bottle in use can be entirely emptied without fear, for should there not be sufficient gas in it to complete an operation, it is only necessary to turn on the other bottle.

After the operation is completed, if another full bottle is not to hand, the Double Union can be removed, and the Union of the Cattlin's Bag fixed to the remaining bottle, while the empty one is being refilled.

GASOMETER FOR LIQUID GAS.

For use in the Operating Room.

Fig. 10.

THIS Gasometer is made expressly for holding Liquid Gas, to be used in the Operating Room. The bottle, containing the gas, is held underneath by two iron rings secured with two screws, and is attached to the Gasometer by means of the union on the bent pipe shown in the engraving. The brass tube with stop-cock, over the bent pipe, is for connecting the Gasometer with the Mohair Tubing to which the Facepiece is attached. The central brass rod, which is divided into intervals of two gallons each, indicates the quantity in the Gasometer at any given time. To insure having sufficient for each operation, it should be filled for each patient.

When the bottle is empty, it can be replaced by a full one in a few minutes.

Most of my readers who remember the Dental Hospital, Leicester Square, in the days before Mr. George Parkinson's great improvements, as regards the making of the gas, were carried out, remember this apparatus.

PORTABLE LIQUID GAS CASE.

To hold Complete Outfit for the Anœsthetist when visiting.

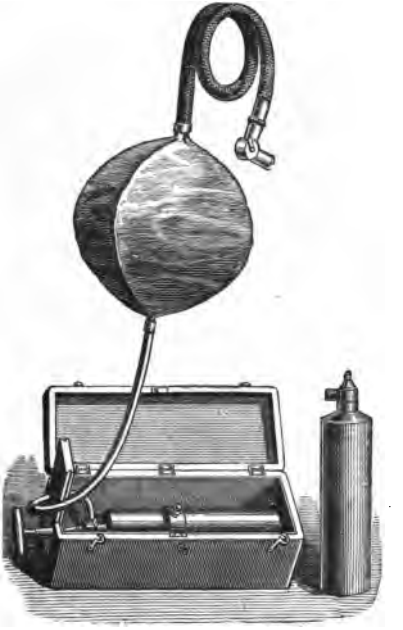


Fig. 11.

In addition to the bottle of gas and Cattlin's Bag shown in the cut, the case will hold a Facepiece, Supplemental or Ether Bag, Two-way Stop-cock, Gags, &c.

Probably the special requirements of each anæsthetist would lead to his adapting and arranging a bag that exactly suits him; the above is, however, a very neat and compact arrangement.

ETHER INHALER.

(Dr. Ormsby's.)

Fig. 12.

Directions for use.

Pour one ounce of Anhydrous Ether—specific gravity 0·720—on the sponge in the cone-shaped wire cage, and the Inhaler is ready for use. After eight or nine good inspirations of Nitrous Oxide, change the Gas Facepiece for the Inhaler. This must be done very rapidly, so that the Nitrous Oxide which the patient gets rid of by the first expiration passes through the sponge and becomes charged with Ether vapour for the first inspiration. Complete anæsthesia is produced in about two and a half minutes.

The illustration on the next page shows the Inhaler in use.

This Bag possesses the same advantage as the Supplemental Bag (shown in Fig. 4, page 94) in so far that its rhythmical emptying and refilling indicate to the administrator the exact state of the function of respiration.

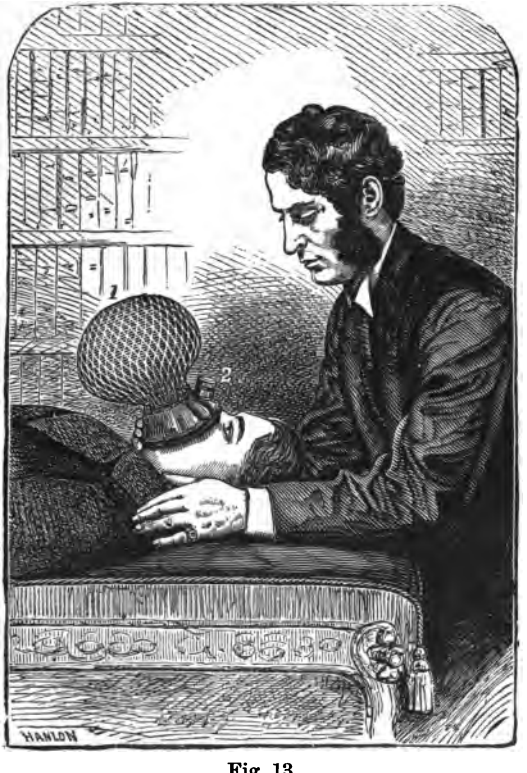


Fig. 13.

Description:

No. 1. Flexible India-rubber Bag covered with netting to prevent undue expansion during expiration.

No. 2. Facepiece of soft metal, which can be readily moulded to any face, covered with leather and provided with moveable India-rubber Pad.

The valve of the Facepiece serves for two purposes:

A. To admit air if required, or to allow its escape if necessary.

B. Additional Ether can be poured down the tube leading to the sponge without removing the Facepiece.

I may add that the position indicated in the figure is not such as would be advisable during a dental operation, the sitting posture being of course preferable.

CHLOROFORM INHALER.

(MR. BIRD'S.)

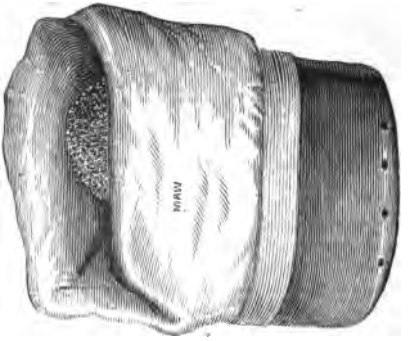


Fig. 14.

CHLOROFORM INHALER.

(JUNKER'S.)

Fig. 15.

THIS Inhaler acts on the same principle as a common scent-spray. The syringe-like part ends in a tube that pierces the stopper and goes down nearly to the bottom of the bottle; the tube ending in the facepiece commences in a stiff portion that only just pierces the stopper. The bottle is filled with the anæsthetic, the little hook is attached to the operator's button-hole, the syringe ball is alternately squeezed and relaxed, and within a few seconds a fine spray passes through into the facepiece. Some maintain that only about four per cent. of the vapour can be blown through; of course the higher the temperature the more vapour will pass through. Mr. Bailey adjusts a mouthpiece like that of a baby's bottle, instead of the facepiece, for long mouth operations, such as cleft palate, &c.

MOUTH OPENER.

Fig. 16.

As will be seen from the engraving the blades of this instrument are provided with transverse slots to prevent slipping. By means of the thumb-screw great power can, if necessary, be gradually applied.

It is usually advisable to introduce the instrument at some point where there is a tooth deficient, but should there be no gap, it is possible with care to insinuate the thin blades between closed teeth. The idea of padding the working surface of the instrument does not appear to me very useful, as the padding would be always torn off in any attempt to force the blades between the teeth.

TONGUE FORCEPS.

THIS to my mind is the best form of Tongue Forceps that can be employed, because it does not slip, and is strong enough to do all that is required of it. The sharp serrations on the inner surfaces of the blades are of great service in securing the tongue, and the slight puncture which they make probably assists the reflex stimulus.

Fig. 17.

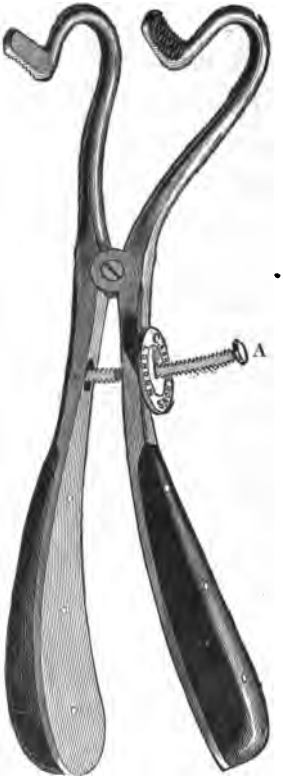


Fig. 18.

ADJUSTABLE GAG.

(Mr. F. Mason's.)

This Gag can be secured at any height by means of the adjusting screw on the moveable rod A. The beaks are padded with india-rubber, for the patient to bite against, to protect the enamel of the teeth from injury.

It is of great importance that the joint should work very loosely, and that the little screw should be so adjusted as to admit of the handles being opened and the blades closed. If it is difficult to work with one hand, it is worse than useless, because, on those occasions when it is required, there is never any time to be lost in fumbling with the screw, quickness of application being absolutely essential to its successful employment.

It will be found very useful when the ordinary gag slips and the mouth spasmodically closes, and also when the operator desires to extract on both sides at one sitting, and success depends upon the rapidity with which the gag can be changed from one side of the mouth to the other.

It is likewise important when the beaks are shut and the handles fully extended, that the latter should not be so far apart that they cannot be fairly grasped with one hand.

MOUTH GAGS.

Fig. 19.

The Mouth Gag, illustrated in Fig. 19, appears to me, among many good ones, to be the best. The essentials in a gag are:

1. That it should be as little in the way as possible.
2. That it should *never slip.*
3. That it should *be easily cleaned.*

It is better to have several sizes than one which will adjust, for the simple reason that the adjusting part, whether it be a screw or a spring, has the *appearance* of being difficult to clean, and *appearance* is very important when a fastidious patient has to hold an object in his or her mouth for some time. It is a comfort to see at a glance that it can be perfectly cleaned in a few seconds. The gag here shown, being made of metal, nickel-plated, has this advantage to perfection; and the shape is calculated to prevent it from slipping when used at the side of the mouth, because the teeth rest the whole surface of the pads, instead of only on one corner.

Two gags should always be connected by a strong thread to prevent the possibility of the one in use being swallowed. A couple of corks tied together with a V-shaped incision at each end, will form a workable, though very clumsy make-shift; but gags made of wood, cork, or any absorbent material, should be destroyed after having been used once, for self-evident reasons, and this constitutes, I think, a serious objection to their employment.

The above shape was first shown to me by Mr. Pillin, a late house surgeon at Leicester Square, who kindly made several in vulcanite for me. I cannot conceive of

anything better, firmer or cleaner, but I think the metal ones, which Messrs. Ash and Sons undertook to make at my suggestion, look cleaner, and are free from smell.

I may add that it is a somewhat dangerous habit to pull away the gag, and operate without. I have seen some very bad bites result from the practice, in nitrous oxide cases, but the muscular relaxation under ether renders the gag less important.

While going to press, two very interesting cases have been brought to my notice by my friend Mr. Alfred Smith, which, although very exceptional, so far as I am aware, demand attention.

The first was the case of a healthy young woman, with apparently strong teeth. Mr. Smith intended to remove a molar on each side of the upper jaw, and the patient, who complained of tenderness in a lateral tooth, begged that the gag might be allowed to rest on the central only. This was done, but as soon as she became unconscious the mouth closed, and forced the central clean out of its socket. The tooth was replaced, but there was nothing to indicate beforehand that it was not firmly implanted, or to raise the suspicions of the surgeon. The other case was one of a canine which stood alone, and such teeth are never supplied with much alveolus; this also was forced from its socket.

The moral I would deduce from these cases is this: first, never place the gag further forward than the bicuspids if it can be helped; but if this is unavoidable, place it between the incisors and select a gag which involves two or more teeth; and, secondly, beware of applying the gag to upper front teeth which project much, for the danger in such cases is considerably increased.

Fig. 20.

Fig. 21.

Fig. 22.

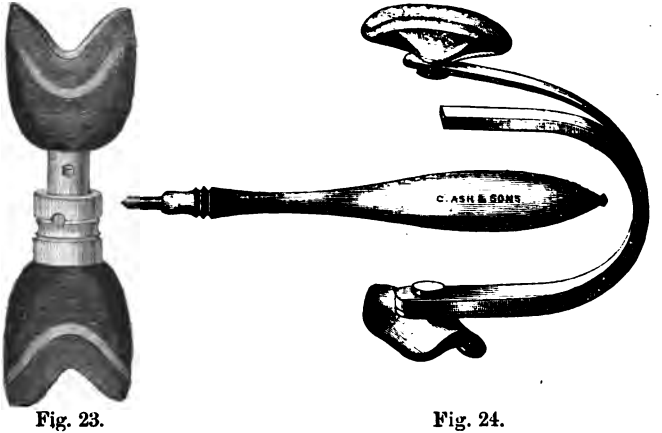


Fig. 23. Fig. 24.

For the convenience of those who differ from me I here insert five of the best Spring Gags.

MOUTH GAGS.

Description:

Fig. 20. Spring Gag in steel, nickel-plated, with gutta-perch pads for the patient to bite into, to prevent slipping. By means of the nut shown on the screw of the upper part, it can be adjusted at any height.

Fig. 21. Spring Gag (Mr. Buck's) in steel, nickel-plated, with screw to raise and lower, india-rubber pads, and knuckle-joint which adapts itself to the dental arch.

Fig. 22. Spring Gag (Mr. Woodhouse Braine's) in ebonite.

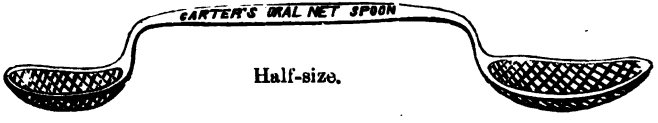
Fig. 23. Spring Gag (Mr. McAdam's) with ivory centres, vulcanite ends, and soft india-rubber pads. The point on the handle is placed in the holes shown in the illustration until the patient bites the pads, when it is released, and, being attached to the stem of the gag by means of stout silk cord, allowed to hang out of the mouth.

Fig. 24. Hinged Gag (Mr. Hutchinson's) with steel spring nickel-plated. When applied, it can be swung against the cheeks, out of the way during operations.

ORAL NET SPOON.

(Mr. T. S. Carter's.)

Fig. 25.



Half-size.

For use during extractions under Anæsthetics.

Mr. Carter gives the following description of this instrument in the *Journal of the British Dental Association* for January 1885:—

"Owing to the increasing use of Anæsthetics for Dental purposes a serious danger has arisen, viz., that of a tooth or stump escaping from the forceps and passing into the larynx when the patient is in a recumbent position and under the influence of an anæsthetic. The position favours its falling backwards, and the lessened sensibility of the glottis, added to the rush of the current of air during an inspiration, renders the patient particularly liable to the occurrence of an accident of this kind.

"By the use of this instrument not only may an obvious danger be avoided, but a great source of anxiety is removed from the mind of the operator."

PROBANGS.

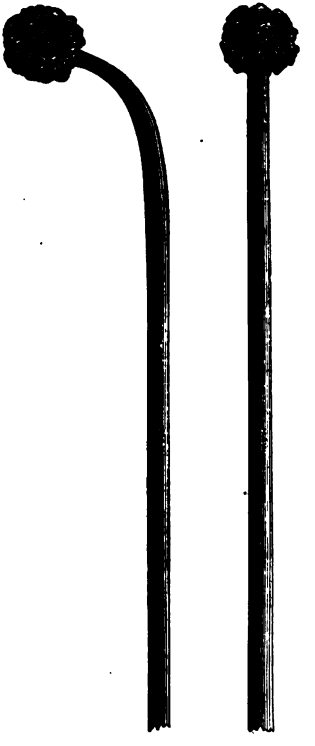


Fig. 26, Fig. 27.

Simple Probangs, curved and straight.

DRESSING FORCEPS, &c.

Fig. 28.

Fig. 29.

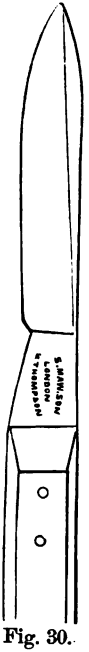


Fig. 30.

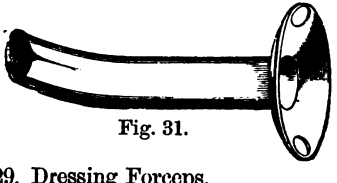


Fig. 31.

Figs. 28, 29. Dressing Forceps.
Fig. 30. Scalpel.
„ 31. Tracheotomy Tube.

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